Installing OEM Multi-Function Steering Wheel (MFSW) with Tiptronic Controls and Heater into a post 2001 model year C5 Platform Audi A6

Part 1: Research and Design

Part 2: Implementation – to follow

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Review Team: Lee Hicks and Ted Basile

Parts for Prototype supplied by: Martyn Franklin, Vagparts.

Summary

This document shows how owners of C5 platform A6 or allroad vehicles with an Infotainment CAN Bus are able to safely take advantage of the all the valuable functionality that a CAN Bus based multi-function steering wheel can provide. This significantly enhances the user experience of the RNS-E and BT telephone installations that have been so thoroughly documented on the Navplus.US forum. Most of the information will also be relevant to the B5, D2 and TT platforms. It also applies to these models if you have a manual gearbox and/or do not want a heated wheel. It does not apply to B6, B7 or A3 platforms.

If the MFSW system is not provided at the factory on an Audi A6 C5 platform there are no components that support it included in the vehicle build. The work documented here is novel and differs significantly from what has been recorded elsewhere by giving comprehensive details of the research and design work required for implementation. Challenges particular to installation in rest of the world models have been addressed as well as those for vehicles built for the USA market.

Part 1 covers research and design

Part 2, to follow in late December 2006 will be a photographic record of the implementation

Please raise any comments or change requests via the MFSW C5 Research & Design Paper thread in the Navplus.US Multimedia section.

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Document History and Planned Future

DATE	ISSUE	COMMENT
4th Sept 2006	Part 1, Draft A	Creation Date
22nd Sept 2006	Part 1, Draft B	First Cut: Draft contents "teaser" released
30th Sept 2006	Part 1, Draft C	Target date for review draft
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5th November 2006	Part 1, Issue 1	Formal Release: Research and Design only
30th October 2006	Part 2, Draft A	Creation Date: Includes Implementation
20th December 2006	Part 2, Issue 1	Formal Release: Photo essay

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Photo 1 The Prototype Vehicle

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1 Preamble

1.1 Warnings

A properly installed multi-function steering wheel provides a significant improvement to the safe use of the vehicle. To achieve this, care has to be taken during the installation.

Part 1 is a research and design guide. Implementation of this will require a reasonable degree of automotive technical competence. This document does not purport to guarantee you, or people who use the vehicle you work on or any others will be safe if you follow it as so much depends on the care you take.

You would have to remove the existing air bag and you would have to fit a new air bag. These are potentially hazardous undertaking for two reasons.

1) If you installed it wrong – and that means in any way that Audi do not approve (e.g. different wiring, different connectors) - and it did not deploy when it should, or deploys wrongly – you might very well be held be financially and morally liable. Your liability might well continue even after you sold the vehicle. You might also invalidate your insurance and invalidate your vehicle type approval, both of which would make it illegal to drive the vehicle. *For the avoidance of doubt, I do not support connecting single stage air bags to two stage controllers or two stage air bags to single stage controllers.*

2) Air Bag installation is potentially dangerous to the installer. Air bags inflate very fast. They are designed with the idea that the occupant they are saving is a little distance away, sitting in the car seat. They are not so safe if they deploy when any part of a person's body is close to them. In the worst case, an air bag might kill. Do not try and test for igniter circuit continuity – you would be likely to cause the air bag igniter to fire and the bag to deploy.

In at least one US State, unlawful tampering with air bags is a criminal offence. See Appendix. If this applies to you, you need to check that what you do is lawful.

Do not drive with the air bag disconnected. You would probably invalidate the personal injury cover element of your car insurance.

It will be necessary to recode controllers responsible for the stability and braking performance of the vehicle. This is a critical safety issue. If you did it wrong again you might be held liable. Again, your liability might continue even after you sold the vehicle.

For implementation you would be connecting wiring at a number of points on the vehicle. If you were to do this wrong you might damage the vehicle, the existing wiring and components, or those components you would have purchased to fit.

If you are colour blind, you need help with this project to identify colour coded cables. Please do not try and implement this on your own.

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1.2 Costs

I used new parts and obtained them from VAGParts in the UK. The full costing is given in the appendix. You can reduce the costs by about two thirds by searching for these parts through on-line scrap yards and e-bay. Ted Basile – who is also implementing similar work – tells me his US dollar costs were:

MF Air Bag	$250
Walnut/Leather 4 spoke Tip Wheel	$100
MFSW Controller Module	$125
Slip Ring Unit	£50
Misc Wiring	$50

Both Teddy and I counsel caution if you buy a pre-owned air bag. Make sure you know the seller and the history of the air bag. There are stolen units and fakes out there.

1.3 Copyright

Audi AG owns the copyright in Audi maintenance and service information. Similarly, Bentley Publishers own the copyright for information they produce under licence from Audi AG. Extracts here are made under the terms of the UK Copyright Act 2003. This tightened the previous UK fair disclosure terms to harmonise with the approach adopted across the European Union. Fair disclosure extracts are still permitted, but they must not be used to support any commercial undertaking. If you want to use this information for commercial activities then you must own an authorised copy of the documentation. Basically this means you paid Audi or Bentley for it. I have indicated where I know copyright exists with the © symbol.

I as the author own and retain the copyright in this document.

1.4 Scope

This project makes the retrofit of MFSW functionality, with all the benefits that it brings, available on vehicle platforms where it was previously not regarded as viable.

The prototype vehicle for this research and design is a 2003 model year UK Audi C5 platform allroad. It has a 2.5 litre diesel engine, and is of course right hand drive. That makes it somewhat different from other European or US models.

This document cannot replace doing ***your*** research for ***your*** vehicle. There are too many variations. It has been prepared using "best endeavours". A number of people have collaborated to get what is written here as accurate as possible, but as author, any errors are mine, and mine alone.

1.5 Workshop Manuals

This work is fairly complex. That is why this document is so large. I strongly advise that if you do decide to implement this you make sure you read and understand the relevant sections of the Bentley or erWin manuals.

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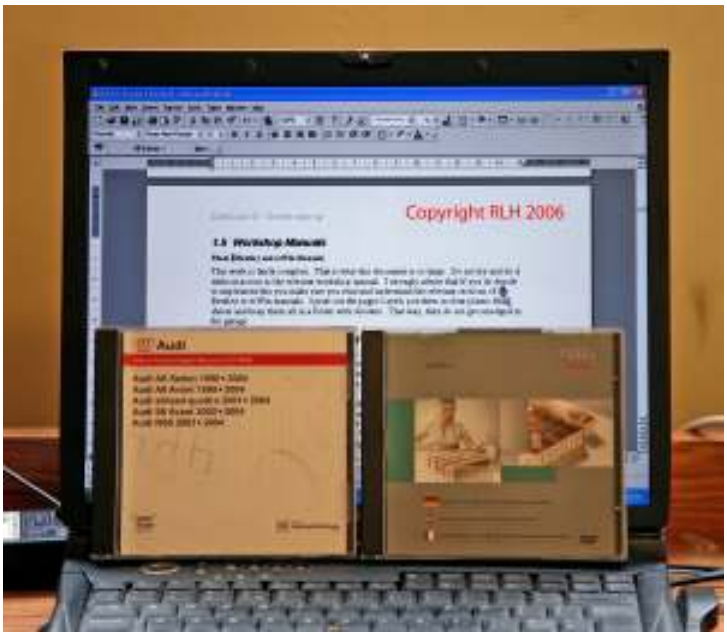
Photo 2 Bentley and erWin Manuals



Andy Smith at Ross Tech, with whom I have been in touch, also strongly recommends access to the workshop manuals if you are contemplating this work.

I print out the pages I need, put them in clear plastic file sheets and keep them all in a folder with dividers. That way, they do not get smudged in the garage.

1.6 USA Versus Rest of World

Information is more freely available in the States. However, what is published there tends to relate only to the States. There are some very significant differences between USA and Rest of the World Vehicles and without knowing some of them you will not be able to implement this work on a non USA C5 platform Audi A6.

The principal problem is that you will need to calibrate a new steering angle sensor. This is required regardless of which market your vehicle was built for. It is in a unit that has to be changed. To do this you have to enter Login and Recode codes to gain access to the relevant controller. Codes documented in USA publications relate only to USA vehicles. They do not necessarily cover others. In particular they do not cover those with diesel engines. I have included the European codes and the procedure that uses them in this document. Please note the copyright restriction.

You would also need to know how to recode other controllers (Instruments, RNS-E, Telephone etc) so that they would know that an MFSW was present. For completeness I have covered or referenced this.

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1.7 Acknowledgements

- Martyn Franklin at Vagparts UK for patiently identifying and sourcing the myriad Audi parts needed so quickly. Many candles were burnt.
- Sebastian Stange for Openodb.org – without his work, this would be much harder.
- Lee Hicks for valuable advice on selecting the MFSW controller, review comments and general encouragement.
- Ted Basile for review comments and for *that* inspirational photo.
- Hervé and later 'Boston Driver' on Audi World for how to connect to the Tiptronic switch – see references.
- Andy Smith at Ross Tech for guidance on procedure and coding details
- PROXUS for earlier showing it could be done on other Audi's
- Vehicle Wiring Products, UK, for the wiring, harness tape etc.
- Audi AG for, well, you try doing it without the documentation! Or the Parts.
- … And finally, all who posted items and questions anywhere about MFSW. You all helped. Thank you.

1.8 Conventions

Connector references follow the convention used in the Audi wiring diagrams. They are shown as T<n><l> where <n> is the total number of pins in that connector and <l> is the connector designation. Adding a forward stroke and then the pin number specifies a particular pin. For example, T5d/1 is pin 1 of 5 pins on connector T5d. For extra information I have also recorded the colour of the connectors and the size and colours of the wiring going to the various pins. Note that yellow housings mean "Air Bag" circuit.

I have tried to remember to give dimensions in inches and metric where appropriate. For threads, of course, it's all metric. Wiring sizes in the text are given in metric and AWG. The metric size is the cross sectional area in square millimetres, not the diameter. I have also included a conversion table in the appendix to convert to AWG. The order multiple from my cable supplier is also in metres.

1.9 Technical Skills

You need access to a really good Audi parts man. I was very fortunate. Lee Hicks kindly put me in touch with Martyn at www.vagparts.co.uk. Martyn has gone out of his way to help, and I cannot recommend Martyn and his firm too highly. An expert on Audi parts is needed not just to identify components, but also to endeavour to ensure they are compatible with one another and to help you with the inevitable problems that will arise. It's well worth a few beers or a bottle of wine or two. Even some headache tablets seem to be welcome!

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1.10 Glossary

ABREVIATION	MEANING
4B	Audi chassis designation
A4	UK Paper size (No, not the car!)
A6	Audi Model (there is, of course an A6 paper size …..)
ABS	Antilock Braking System
Audi AG ™	Audi Aktiengesellschaft (Audi Incorporated (PLC in UK)
AWG	American Wire Gauge
C5	Audi Platform Designation
CAN	Controller Area Network
CD	Compact Disc
Compens.	Compensation
DIS	Drivers Information Display
DVD	Digital Versatile Disc
erWin ™ ©	Official Supplier of Audi Service data in Europe
ESP	Electronic Stabilisation Program
ETKA ©	Elektronischer Teilekatalog (Electronic Catalogue)
FAQ	Frequently Asked Question
FRN-G	Type of brake calliper made by Continental Teeves
GBP	Great Britain Pounds (£)
GHz	Giga Hertz (1,000,000,000 cycles per second)
ISO	International Standards Organisation
J217	Audi designation of automatic gearbox controller module
J453	Audi designation of MFSW controller module
K15	Ignition switched power supply (accessory on)
K30	Always on power supply (Battery via 150 amp fuse)
LIN	Local Interconnect Network – a slow speed data bus
Ltd.	Limited Company (Public or Private)
M12	12 mm diameter metric thread or tool.
MFSW	Multi Function Steering Wheel
MHz	Mega Hertz (1,000,000 cycles per second)
NF	New Fuse
OBD	On Board Diagnostics
OEM	Original Equipment Manufacturer (in this case, Audi)
PLC	Public Limited Company
PVC	Poly Vinyl Chloride
RNS-E	Radio Navigation System type E
S326	A fuse
TLA	Three Letter Abbreviation
TORX ™	ISO 10664 standard hexalobular drive system developed by Textron ™
UK	United Kingdom
USA	United States of America
USB	Universal Serial Bus
VAG	Volkswagen ™ Audi ™ Group
VAG Com	Specialised non-Audi hardware and software tool used to read faults and program controllers on VAG vehicles. Available from Ross Tech.
VIN	Vehicle Identification Number
Wiki	Wikipedia – Internet hosted Encyclopaedia
75X	Load Reduction Power Supply
XP ™	eXPerience – Microsoft's current operating system.
XZN	Triple square (twelve spline) nut driver tool.

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2 Introduction

The prototype vehicle VIN is WAUZZZ4B23Nxxxxxxx. The intention is to get as close as practical to the ex-factory look and feel.

It became clear to me during the review process that this research and design document would be all the better for being released after implementation has been completed, so that is what has been done.

One of the reasons I produced this document was that I found I was very unclear in my mind about what all the bits and pieces were, where they were sited, and how they interacted with each other. It's quite easy when you can go out and look in your vehicle to see how it is done; it is not quite so easy if none of the bits are there in the first place. You can learn from my mistakes.

One useful thing to know early on is that a minimum amount internal trim has to be removed to do this work, particularly if you do not want to add the Tiptronic control function. Even with Tiptronic trim removal and refitting is not difficult. You need to take care, and use the right tools – in this case, a putty knife! Full details will be shown in Part 2.

If you have a Tiptronic box, and you want to add the ability to change gear from the steering wheel, then there are two very good articles on Audi World you should read. They are about installing Tiptronic (or Paddle) buttons and they give excellent detail about how to remove the trim around the selector. See the reference section at the end of this document.

Early C5 platforms, with the analogue clock, do not have a CAN enabled cluster and this work is not relevant to such vehicles.

The next page shows a block schematic of the MFSW sub-system.

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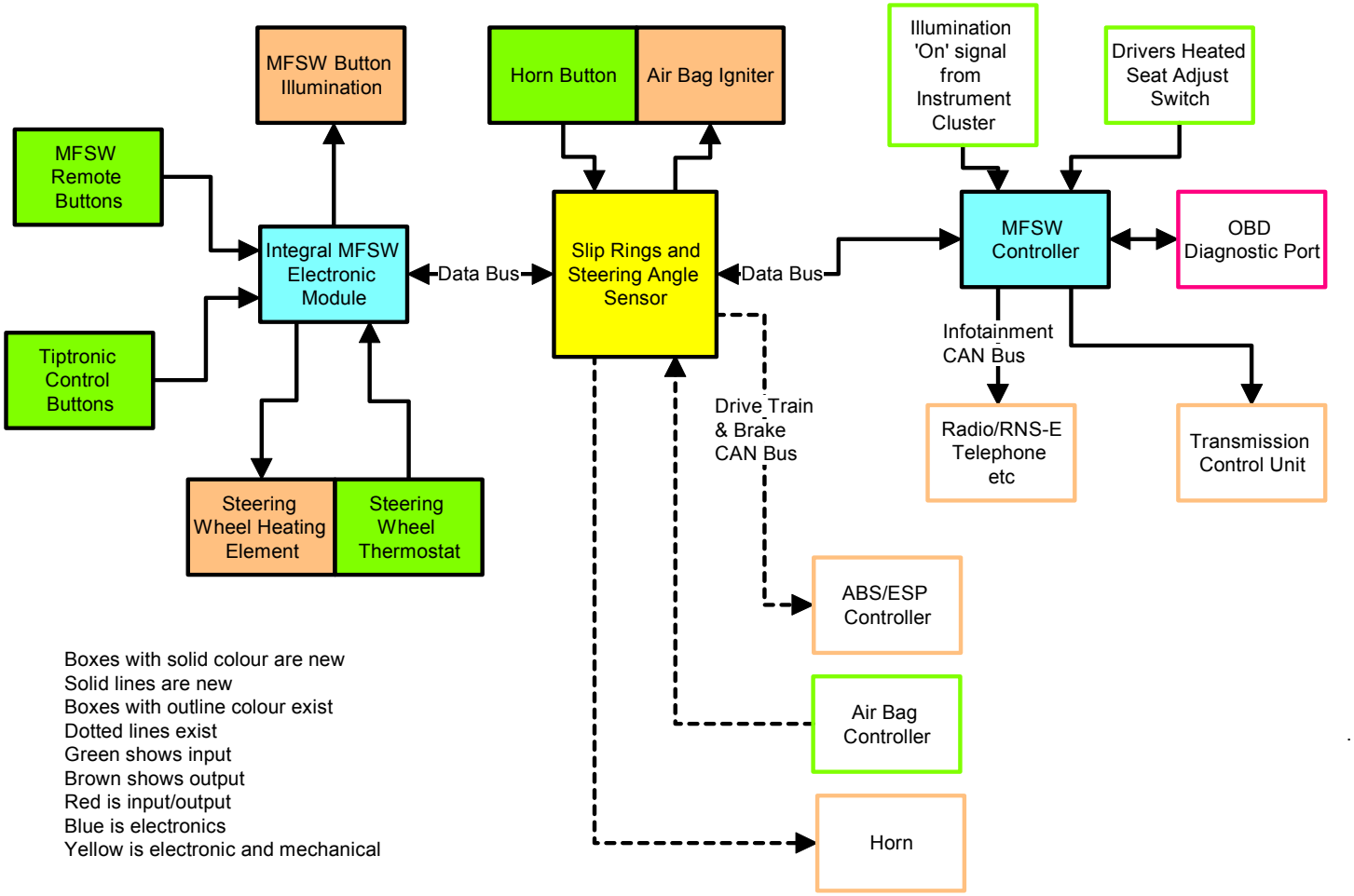
Figure 1 Block Schematic



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MFSW functionality is implemented by Audi by means of a MFSW equipped with a number of buttons. There are buttons mounted on the air bag to control Navigation, radio and telephone functions and you may also wish to have buttons on the wheel rim to control the Tiptronic gearbox – if you have one.

These buttons drive an integral electronics module mounted inside the steering wheel. This module talks to a MFSW controller via a single wire data bus. The wiring between the electronics in the rotating MFSW and the rest of the vehicle is connected via "clock springs" and "slip rings" inside a unit positioned just behind the steering wheel.

Electrical signals from the horn buttons and to the air bag igniter also pass through this unit.

The MFSW controller writes data to the Infotainment can bus. This data enables the Radio, CD player, navigation, telephone and other units to be controlled remotely by pushing buttons on the steering wheel. The controller also can also send instructions to turn the steering wheel heating and lighting on and off. The controller also interfaces with the on board diagnostics port and may also be interfaced with the Tiptronic Gear selector switch (this is not done by CAN-bus on the C5). The MFSW controller is mounted at positions 7 and 8 on the 13-way relay panel that is housed behind the driver's storage panel.

There is no MFSW functionality fitted at all in the prototype vehicle. No buttons on the wheel, no MFSW electronics for the buttons to drive mounted behind the steering wheel, and no MFSW controller mounted on the 13-way relay panel. There is no wiring harness from the wheel to the controller location.

Photo 3 Where the MFSW Controller goes

Repair wires are fitted to a dual relay plate. The plate then clips into the two square holes and the controller, which looks similar to the '393' module in the picture, fits into the dual relay plate.

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The only component required that is fitted in a non-MFSW equipped allroad is a five-pin connector as four of its pins are already used to enable non-MFSW functionality – the air bag and the horn.

Section three is a walk through of the various brought in components. Section four discusses how to interface the MFSW controller with the vehicle. Section five discusses the cable runs required to do this. Section six shows how these runs can be grouped together to form harnesses.

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3 Bought In Component Walkthrough

This walk through of the various components you will need to purchase starts with the steering wheel and then works along the signal paths towards the multi-function controller. If you are not implementing all the functionality described in this paper, you will not need all these components, and in some cases can use different part numbers to save money. This is indicated in the appropriate section.

3.1 Introducing ETKA and Audi Part Numbers

Audi ETKA is © Audi AG. With very few exceptions all the parts in your Audi will be listed in ETKA. This is a German abbreviation for Elektronischer Teilekatalog – Electronic Catalogue of Spare parts. It is available to Audi dealers and can also be found on the Internet. I leave it to the reader to locate access to one, as I do not wish to infringe Audi's copyright. The obvious alternative is a kindly Audi parts supplier.

ETKA shows various sub-systems as an exploded diagram, with the parts all numbered followed by a comprehensive parts list.

This reference gives a good explanation of the part numbering scheme:-

http://www.vagparts.com/pages/partno.htm

3.2 Repair Wires

Audi no longer supply contacts only for connectors in the UK. You have to buy repair wires, which are 600 mm long (about 2 ft) and have a contact pre-crimped onto each end. You get two contacts per wire. I have listed the repair wires needed against the parts below. However, there is an alternative, which will save a few Pounds /Euros/Dollars. You can obtain these wires from salvage yards quite cheaply by buying up sections of harness and then dismantling them. NSX-JR maintains a database of Audi connectors and pins on his Web Site and we intend updating that to include MFSW connectors and pins. You will need access to a suitable set of pin extraction tools.

3.3 Steering Wheel

3.3.1 Look and Feel

I wanted a four-spoke heated leather rimed wheel. For the allroad C5 platform the buttons controlling the Tiptronic gearbox are mounted on two of the wheel rims. The multi-function radio and telephone control buttons are mounted on the air bag. The rim has a built in heater and temperature controller. Other styles are available. One of the reasons pre-owned heated wheels come onto the market is that the heater function has failed.

The wheel is rigidly fixed to the steering column by splines and a bolt. The spines allow the wheel to be positioned in steps of about 5°.

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Photo 4 The New Wheel

Note: Air Bag ordered separately

ETKA PART DESCRIPTION © AUDI AG	PART NUMBER
Mult-function steering wheel (leather – heated) for vehicles with Tiptronic, Soul (black)	8Z0 419 091 BD 1KT

There is a wide range of wheels available depending on functionality and colour. Consult your supplier.

3.3.2 Functionality

The functionality of the buttons is fully described in the RNS-E navigation unit manual. You can obtain one of these for the remarkably low cost of $5 (including shipping!) from Audi USA. There is also an excellent post by PROXUS at http://www.navplus.us/forum/viewtopic.php?t=2088&start=0&postdays=0&postorder=asc&highlight=

3.3.3 What is included?

If you order a complete wheel you will get some or all of the following bits included, depending on what wheel you specify.

QTY	DESCRIPTION	PART NUMBER	COMMENT
2	Cheese head bolt – to attach air bag	8E0 419 204	Always provided
1	Air bag Harness	8Z0 971 589 J or 8Z0 971 589 K or 8Z0 971 589 H	Always provided, part depends on configuration. Mine is 'J' suffix
1	Wiring harness for temperature sensor	8Z0 971 589 D or 8Z0 971 589 L	Part of wheel, part depends on configuration.
1	Wiring harness for multifunction buttons	8Z0 971 589 E	Provided with MFSW wheel.
1	Right Tiptronic push button	8E0 951 527 P	With harness
1	Left Tiptronic button	8E0 951 527 N	With harness
1	Clip to secure Tiptronic harness	-	Not a replacement part
2	Torx bolts to secure Tiptronic buttons	-	Not a replacement part

If you order a complete wheel, you do not need to worry about these internal parts, they come pre-assembled with the wheel. Three things are not included in the above

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list. These are the bolt to hold the wheel on, the air bag and the multifunction buttons. See below.

3.4 Steering Wheel Bolt

Audi recommend that this is changed whenever it is removed. It is ordered up separately from the wheel. The part number is N90 799 101 and it is a M18 x 1.5 x 18 (all dimensions in millimetres). The reason for changing it is that all bolts stretch just a little when they are tightened. It is how they work and achieve their clamping action. Repeated tightening weakens the bolt. I expect Audi feel you would not want the new steering wheel coming off in your hands when driving, and the bolt is not expensive. You might feel it is ok to reuse the bolt once, making sure you apply Lock-tite (blue) to the threads and not getting it on your nice new wheel. I could not possibly comment!

Photo 5 Wheel Retaining Bolt

A special tool is required to remove and replace this bolt. I have seen this described as a 'Triple Square' or 12mm multi-spline or star-spline driver. I believe it is correctly known as a XZN M12 driver. It differs from the TORX type driver by having twelve rather than six splines. It is easily available from any good tool factor or auto hardware store. I got mine from Halfords in the UK.

Photo 6 XZN M12 Driver

There are reports that this bolt is fairly tight (mine was not). Like most nuts, it undoes anti-clockwise. Make sure you do not break your window screen with a long handle T bar or ratchet. You will need to apply enough force to overcome the thread locking compound Audi used. Lock the wheel in the straight-ahead position first and pull down on the T bar rather than push up. I suspect a ½" drive will be best. An air

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impact driver would make short work of it, but make sure your adapter is rated for impact use. The tightening torque of 70 NM (this is 7Kg/M or 52 ft lb) is well within the range of a standard torque wrench.

3.5 Air Bag

The C5 platform A6 and allroad use a single stage controller firing a single stage air bag. Be aware that there are fake and stolen air bags for sale. The fakes are not easily detected visually. It would also be very easy to fool the air bag controller into thinking it was connected to a real, functional air bag. For guidance, my genuine one weighs in at 4½lbs or 2.1Kgs. They'll probably all put weights in now…..

Photo 7 Air Bag

This is officially an explosive device. They are rated as United Nations hazard category 1.4S for the complete assembly. Care needs to be taken when removing and installing one. In particular, the battery must be disconnected at the negative (ground return) terminal prior to working on the air bag or associated wiring, sensors or controller. Follow the instructions in the workshop manual carefully.

There are a number of different air bag/button combinations depending on what colour and what particular type of MFSW buttons you want. The options are too extensive to list here and would verge on breaching the UK copyright act. Consult your supplier, or buy the buttons you like from a similar vehicle to yours.

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Photo 8 Disconnect Battery

Always disconnect the vehicle battery ground terminal first. On Audi's (and most cars now) it is the battery negative terminal. That way, if you were accidentally to short the battery terminal to the vehicle body with a spanner, it would not matter. Your battery is quite capable of passing enough current between its terminals to heat that spanner so much that it burns you. I've even heard of a spanner being melted.

When working on air bags, Audi recommend disconnecting the battery with the ignition switched on. This minimises the risk of surges and spikes on the power lines or other wiring when the battery is reconnected. Make sure no one is in the vehicle when first reconnecting the battery after reconnecting an air bag. Do not keep air bags uninstalled for longer than absolutely necessary. Be aware that storage of several air bags even overnight may theoretically require a licence. Unwanted air bags need to be deactivated by trained personnel. Should you ever be dealing with a deployed two stage air bag you must assume that only one igniter has fired, and that the other is still intact and could re-deploy the bag. In some jurisdictions, New York State, for example, I understand that it is illegal to sell second hand air bags.

Audi use special connectors on air bag circuits. They are coloured yellow and some have special bridge contacts that short out the air bag circuit when they are removed. This is a safety precaution. Even so, treat the bag with care. Point it away from you when carrying it and store in a clear, cool space away from shelves and things that might get damaged if it deploys.

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Photo 9 Air Bag bridging contacts

ETKA PART DESCRIPTION © AUDI AG	PART NUMBER
Airbag unit for steering wheel with switch for radio, telephone and voice op. remote control. Soul (black)	8E0 880 201 BP 6PS

As I understand it the letters ‘BP’ here indicate the type of multi-function controls. This one is for Radio/Nav, telephone and voice control. The last three digits identify the colour. The multifunction control buttons come with the air bag unit.

Note that identifying this air bag required professional advice, as the original one has been superseded a number of times. Also, the cross referencing on ETKA was incorrect. Wheel ‘A’ cross referenced Bag ‘B’ but Bag ‘B’ cross referenced wheel ‘C’, not wheel ‘A’. Apparently ETKA is not always right. You have been warned.

The bolts that hold the air bag to the wheel are round the back. There are two, one each side, and they have Torx T30 heads. Boston Driver in his article on Audi World (see references) reported that they were very tight. He used a Torx key to shift them. An alternative is a ½” or 3/8” T30 driver and a socket set, which is how I will loosen mine.

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3.6 Multifunction Buttons

Photo 10 Multifunction Buttons

These are ordered up as part of the complete air bag assembly. See section 3.5 above. If you need spares, the part numbers depend on the control functions and the air bag. I advise consulting a dealer or supplier.

3.7 Tiptronic Control Buttons

These are ordered up as part of the complete MFSW assembly. See section 3.3.3 above. If you are not installing Tiptronic functionality, then you obviously do not need these buttons. You can, of course, have a wheel with them and simply not connect the controller to the gearbox selector.

3.8 MFSW Internal Harnesses

There are up to five, depending on which wheel you were to order. They are for the internal electronics module, air bag, multifunction control buttons, Tiptronic control buttons and a temperature sensor harnesses. ETKA shows that all the required ones will be ordered up as part of the complete wheel assembly. See section 3.3.3 above.

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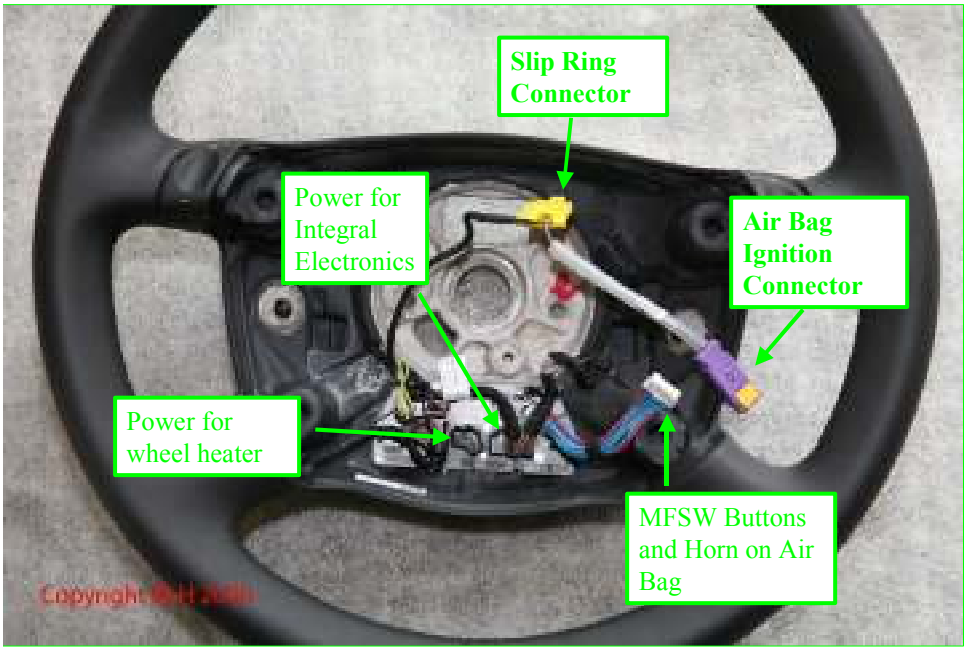
Photo 11 MFSW Harnesses



They connect the air bag, the multi-function radio and telephone buttons mounted on the air bag, the heating element, the temperature sensor for the heated rim and the Tiptronic gear selector buttons mounted on the spokes to the internal MFSW electronics module. The airbag harness connects the horn and the air bag igniter via the clock springs.

3.9 MFSW Electronics Module

This module is integral with the steering wheel. It encodes signals from the multi-function and Tiptronic control buttons onto a single wire low speed data bus (it will use the vehicle ground for return) that communicates with the MFSW controller. These electronics also receive data signals from the controller telling them to switch on the wheel rim heater, or to illuminate the wheel switches. There is a temperature sensor to prevent the wheel heater from over-heating.

The slow speed data bus uses the LIN protocol. The maximum bit rate is 20 thousand bits per second. The review team believe Audi changed the message format between platforms. If you are thinking about a cross platform implementation you need to ensure all the components are compatible.

This module is not available as a replacement part. Audi supply it only with the wheel. There may be different modules depending on wheel functionality.

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Photo 12 Electronics Module - Location

These electronics, the horn button and the single stage air bag igniter are connected to the rest of the vehicle by seven “clock springs”. In addition, two slip rings are used to provide power to run the heated wheel element from the load reduction circuit via a new fuse NF1 - 15 amps, and to provide the ground return.

There is a short harness coming from the wheel side of the slip ring unit terminated in two plugs. The smaller of the plugs provides power to run the integral wheel electronics, the large plug provides power to the electronics module, which it switches to turn the wheel-heating element on and off. The small plug fits fine. The large two pole plug, part number 4B0 971 942, is apparently used mainly for connecting to speakers. It does not fit into the corresponding socket on the electronics module. We are confident we have identified the current correct Audi part for the slip ring unit for this application from ETKA, but clearly there is an inconsistency somewhere.

[We are still working on this. Please check the MFSW C5 Research & Design Paper thread on NAVPlus.US for the latest information]

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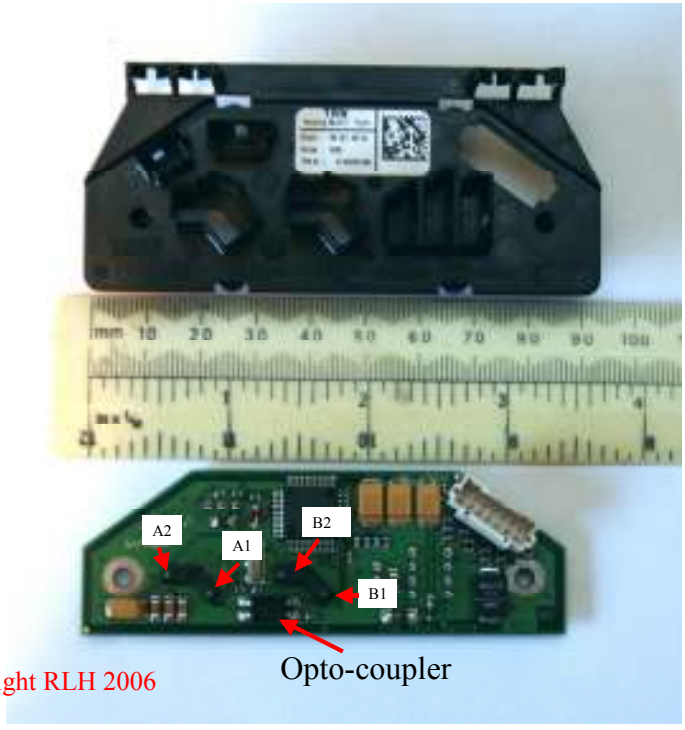
Photo 13 Connector carrying Rim Heat power

We have not been able to identify an adapter, or even a 'counter plug' – a socket – which the 4B0 971 942 plug provided would fit into. It is possible to identify the pin numbering on the incompatible plug, and pin 1 provides the battery feed, with pin 2 being the ground return. It is also possible to identify the pin numbering on the heating element power input socket on the electronics module by comparing it with the power output plug and socket connected to the heating element itself. To double check I dismantled the electronics module and traced the internal connections.

Photo 14 Integral Wheel Electronics Module - Connectors.



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Pins B1 and B2 are the heating element load reduction power inputs; Pins A1 and A2 is the switched 12-volt feed to the heating element. Pins A1 and B1 are joined together, so the switching is done between pins B2 and A2. Pins A1 and B1 also connect to pin 3 of the opto-coupler, which is a SFH6186-3 device. The data sheet for this opto-coupler shows that pin 3 is the collector of the NPN switching transistor inside the coupler. This means that pin 3 must be the positive input, and consequently Pins A1 and B1 carry the +12 volt supply, the rim heating element being switched on the return leg. The ground return is on B2, and pin 2 of the unwanted black connector connects to a solid brown wire, which is the Audi colour code for ground return.

Connector 'A' on the integral wheel electronics is a rather flattened 'V' shape. The socket for connector 'B' – which I don't have – is similar, but 'handed' the other way. Connector 'A' does carry the Audi ring symbol, but the numbering does not correspond to anything published in ETKA. As a result I have had to depart from the OEM approach to deal with this.

I intend fitting some spare terminal pins that I have to make short adapters up that will enable me to connect these wires to the internal wheel electronics module.

Probably one lesson here is that you can expect the odd challenge or two.

Photo 15 Connector feeding power from Module to Heater

3.10 Clock Springs, Slip Rings and Steering Angle Sensor

ETKA PART DESCRIPTION © AUDI AG	PART NUMBER
Cancelling ring with slip ring and steering sensor for vehicles with multi-function steering wheel (ESP – Leather)	1J0 959 654 AG
Cancelling ring with slip ring and steering sensor. Mult. steering wheel (leather) with ESP and heated	1J0 959 654 Q

3.10.1 Description

This unit allows connections from the rotating steering wheel to be transferred to the vehicle without the wires being broken by repeated flexing as the steering wheel is

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turned backwards and forwards. It also acts to cancel the indicators and, where fitted, houses the steering angle sensor. "Clock Springs" are used to carry low current power and signals, whilst two slip rings carry the power for the heated wheel. If you are not installing a heated wheel then you can save over $100 US on the new price of this item – the 'AG' version is available for under $200 new, the 'Q' version, which superseded the 'AL' is over $300 US new. Vagparts can supply these even cheaper.

The steering angle sensor tells the Electronic Stabilisation Program (ESP), if fitted, how far the steering wheel has been turned. ESP uses this to control the brakes and reduce/correct a skid. It is therefore a very important safety function.
The steering angle sensor is connected to the rest of the vehicle through a 6 pole plug on the back of the unit. This connector is unplugged from the old unit and plugged it into the new one.

Photo 16 Vehicle side of Slip Ring Unit

The Factory slip ring unit has to be changed. There are not enough clock springs in the old unit. If ESP is fitted, and it is on the allroad, then changing this unit requires a procedure to be carried out afterwards for the ESP controller so that it knows when the front wheels are centred.

This procedure requires specific Logon and Re-code codes to be entered. These codes are dependent on a number of variables, the vehicle type, engine type, type of brakes and type of transmission. Entering these codes needs the Ross Tech VAG Com tool, or the Audi dealer's vehicle diagnostic, testing and information system, or scan tool.

3.10.2 Determining the Login and Re-code Codes

The Re-code code is the 'Soft Code' you see if you open the controller using VAG Com. Once you know this, you can determine the appropriate Login code. Alternatively the Login and Re-code codes are tabulated in the Bentley manuals, but not for my diesel, as these are not available in the States.

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Details of how to derive the Login and Coding codes for some C5 platform A6 and C5 allroad - light armoured :-) vehicles are given on the Ross Tech Wiki site at: -

http://wiki.ross-tech.com/index.php/Audi_A6_%284B%29_Brake_Electronics_%28Bosch_5.7%29#Coding

You need to check which braking system you have. Mine is the Bosch 5.3 and at the time of writing, this was not covered by the Ross-Tech wiki. By inspection, the ABS control module part number in my car is 8E0 614 111 AS. Ross Tech shows this as the Bosch version 5.3 controller.

My vehicle has 17" rims. Ross-Tech list only one brake calliper for 17", this is the 2FNR 42 AL with a production Code of PR-1LL.

However, the Bentley manual shows three brake calliper pictures, and by inspection I have the FRNG 60. This is manufactured by Continental Teeves. Also, by inspection my brake production code is PR-1LA, which the Bentley manual confirms is for an FNR-G60 calliper (Brakes – Technical data)

Photo 17 FNRG 60 Brake Calliper

Although it is possible to make a good attempt at deriving these Login and Re-code codes, the best way of determining them is to look them up. If you look at the Ross Tech Wiki you will see some inconsistencies listed. For USA models you can readily use the Bentley manuals. For European models – and particularly diesels – you normally would need to access to the Audi Europe documentation. For UK and EU models this is available, at some cost, from http://www.erwin-portal.com/

Your dealer will also recode this unit for you (it's a safety issue!) and some have reportedly had it done without having to pay. For convenience, the codes for European models are reproduced below: Please remember, commercial use of this information from this document is not permitted.

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3.10.3 European ESP Login and Recode Codes

Information in this table is © Audi AG

MODEL	BRAKES	ENGINE	GEARBOX	LOGIN	RECODE (SOFT-CODE)
A6	FN3 Teeves/ATE	4 Cyl Petrol	Manual	07575	06275
			Automatic	07577	06277
			Multitronic	07579	06279
		6 Cyl Petrol	Manual	07595	06295
			Automatic	07597	06297
			Multitronic	07599	06299
	HP2	6 or 8 Cyl Petrol	Manual	07495	06395
			Automatic	07497	06397
			Multitronic	07499	06399
	FN3 Teeves/ATE	4 or 6 Cyl Diesel	Manual	07555	06255
			Automatic	07557	06257
			Multitronic	07559	06259
allroad	HP2	6 Cyl Petrol 2.7L	Manual	07495	06395
			Low Range	07493	06393
			Automatic	07497	06397
		6 Cyl Diesel 2.5L	Manual	07455	06355
			Low Range	07453	06353
			Automatic	07457	06357
	FNRG-60 Teeves	6 Cyl Petrol 2.7L	Manual	07395	06495
			Low Range	07393	06493
			Automatic	07397	06497
		6 Cyl Diesel 2.5L	Manual	07355	06455
			Low range	07353	06453
			Automatic	07357	06457
	HP2	8 Cyl Petrol	Automatic	07487	06387

These codes have been independently checked against the official Audi documentation.

The first digit is always zero. The second Login digit is the second soft code digit plus 1. The third Login digit is the third soft code digit minus 1. The fourth and fifth Login digits correspond to the fourth and fifth soft code digits respectively.

Details of how to use these codes are given on the Ross Tech site at - http://wiki.ross-tech.com/index.php/Audi_A6_%284B%29_Brake_Electronics_%28Bosch_5.7%29
Note however that the codes given are for the Bosch 5.7 controller and USA models.

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3.10.4 Storing Steering Centre Position

- You may need a five digit non-zero Workshop Code set up on your VAG Com. A non-zero WSC is needed for the Bosch 5.3 and 5.7 ABS/ESP controllers. A WSC of 12345 reportedly works fine. Stealth mode does not work with these controllers. If you have different controllers, and are registered with Ross Tech, ask them. They are always most helpful.
- When entering the WSC, use **[Apply]** rather than **[Save**]. That way you will use the non-zero WSC only for this VAG Com session, and it will not be saved as part of the VAG Com configuration file.
- You also need a short flat area for a test drive. This is part of the Audi procedure and is specified to ensure the steering is centred within the required tolerance of ± centred, not just that the steering wheel itself is.
- A portable laptop computer, or a long power lead. ☺

There are four steps: Login, Recode, Test Drive and Store Basic Setting

- Check handbrake is on, select park with an auto, neutral for a manual and start the engine

Using VAG Com, and based on the Ross Tech guidance and the Audi workshop manual:

- **[Select]** 03 Brakes
- **[Login –11]** Enter appropriate Login value from section 3.10.3 above
- **[Do It]**
- **[Recode – 07]** Enter the appropriate Recode value from section 3.10.3 above
- **[Do It]**
- Do not exit controller yet. Do not switch off the engine.
- Turn steering wheel one full turn to the left and back to centre
- Drive a short distance in a straight line at less than 20 Km/h (about 12 mph)
- Bring vehicle to a stop, keeping in a straight line.
- If steering properly centred then: -
- Without moving the steering wheel,
- **[Login –11]** Enter the code **40168**
- **[Do It]**
- **[Basic Settings – 04]**
- Group 001
- **[Go!]**

This will have stored the centre position of the steering wheel. There should be a message that says, “Steer angle sender compens ok”.

You can now exit the controller.

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If the steering wheel was not properly centred, then it is most likely you have put the new wheel on incorrectly. Reset it on the steering column splines and start again. Do not forget the new bolt! In other words, get this right the first time.

The following table sets out some possible error messages, why you got them, and what to do about them.

ERROR	LIKELY REASON	ACTION
Function is unknown or cannot be carried out at the moment	You have not logged in correctly	Turn off ignition. Check both your codes. Start procedure again
Compens. steering angle not ok	See Diagnostic Trouble Code Memory	Check DTC memory, erase memory, switch ignition off and back on and try again. If problem persists, check your ESP wiring.
Compens. steering angle blocked	You forgot to turn the steering wheel right and then left	Switch ignition off and back on and try again

If you are still having problems you will need to consult the workshop manual or consult your dealer. Expect to pay.

If you are not able to successfully Login, Recode or set the centre position, or if you attempt to perform this procedure with a zero (stealth) work shop code, the ABS light will come on and stay on and an 'invalid coding' fault will be stored in the controller

3.11 New Slip Ring to vehicle connectors.

Excluding the ESP connector, which is reused, there are three other MFSW system connectors that connect the slip ring unit to the vehicle. In general, when ordering, you need a housing and some matching repair wires. You buy the appropriate repair wires, which have a connector on each end, cut each in half, plug them into the correct pin location and crimp or solder them to your new harness wires.

3.11.1 T2bg, Black, 2 pin

This is a 2 pin black connector. It is only needed with a heated steering wheel. It is not present in my vehicle and has to be provided and will be located behind the steering column switch trim. It will connect a load reduction battery feed from new fuse 1 - 15 amps, and ground return to the internal MFSW electronics.

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Photo 18 Connector T2bg

ETKA PART DESCRIPTION	PART NUMBER
Connector, black, 2 pin	893 971 632
Repair wire (1 off = 2 contacts)	000 979 133

PIN	WIRE COLOUR	WIRE SIZE	FROM	TO
T2bg/1	Black/yellow	1.0	Fuse S227 15 amp – Wheel heater fuse	Electronics
T2bg/2	Brown	1.0	T5h/3	Ground

3.11.2 T5d, Yellow, 5 pin

This is a 5 pin yellow connector. It should be already present located behind the steering column switch trim. Four of its pins are used to connect to the horn and the air bag igniter via the slip ring unit. The remaining pin 1 location will be vacant, and I had expected a repair wire would be available to enable T5d/1 to be used to connect the data bus that carries signals between the MFSW internal electronics module and the MFSW controller.

It turns out that ETKA doers not list such a repair wire. Instead, it appeared at first that a new complete and expensive pre-wired connector was required. Audi also specify two special heat shrink connectors to be used in conjunction with it. These are for use on the air bag igniter circuit.

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Photo 19 Connector T5d

ETKA PART DESCRIPTION	PART NUMBER
Connector T5d (Yellow)	6E0 971 582C
T5d heat shrink connectors	111 971 941A

PIN	WIRE COLOUR	WIRE SIZE	FROM	TO
T5d/1	Red/yellow	0.5	Electronics (Bus)	MFSW Controller J453 pin 18
T5d/2	Brown	0.5	Horn button and igniter shield	Ground
T5d/3	Brown/white	0.5	Horn button	Low tone horn
T5d/4	White	0.5	Air Bag Controller	Air bag igniter negative
T5d/5	Yellow	0.5	Air Bag Controller	Air Bag Igniter positive

However, Lee Hicks's Audi Pins database indicates that a repair wire 000 979 018 will fit into T5d. This will mean that there is no need to replace this connector; T5d/1 is simply equipped with a repair pin. I ordered up a pre-wired T5d connector and can confirm this is the case. The part number was slightly different from that shown on Audi Pins. Mine (now for sale!) looks like it has been through a value-engineering program.

The bottom line is that you should be able to use your existing connector – see Part 2. If you look at the parts order in the appendix, you will see how much money you have just saved!

3.11.3 T5h, Black, 5 pin

This is a 5 pin back connector. It is not present and has to be provided and will be located behind the steering column switch trim. It will connect a new 1 amp fused supply and ground return to the internal MFSW electronic module.

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Photo 20 Connector T5h

ETKA PART DESCRIPTION	PART NUMBER
Connector, 5 pin, Black	4B0 973 605
Repair wire (1 off)	000 979 018

PIN	WIRE COLOUR	WIRE SIZE	FROM	TO
T5h/1	-			
T5h/2	Black/red	0.35	Fuse S236 1 amp	Electronics
T5h/3	Brown	0.35	Electronics	T2bg/2 and ground
T5h/4	-			
T5h/5	-			

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3.12 MFSW Controller (J453)

Ted and I are very grateful to Lee Hicks for his guidance on this unit. Check out the excellent download section on his web site at http://www.nsxjr.com/ for other valuable information.

Photo 21 MFSW Controller

The generic term for these controllers on the wiring diagrams is J453. There are two flavours. A '616' that does not support Tiptronic, and a '618' that does.

ETKA PART DESCRIPTION © AUDI AG	MODULE TYPE	PART NUMBER
Control Unit for multi-function steering wheel without telephone or for preparation for telephone	'616' No Tiptronic	4B0 907 487 F
Control Unit for multi-function steering wheel without telephone or for preparation for telephone	'618' With Tiptronic	4B0 907 487 H

The pin out is given in section 3.13.

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As far as the review team know, these are only two controllers that can be used in CAN bus equipped cars. The controller is mounted at positions 7 and 8 of the 13-way relay panel. These are the two lower left positions. The controller communicates with the steering wheel electronics using a slow speed data LIN Bus.

The controller has to be coded after installation. The Bentley Manual shows incorrect coding. The correct codes are:

For the non-Tiptronic '616' controller, soft code = 0100?
For the Tiptronic '618' controller, soft code = 0101?

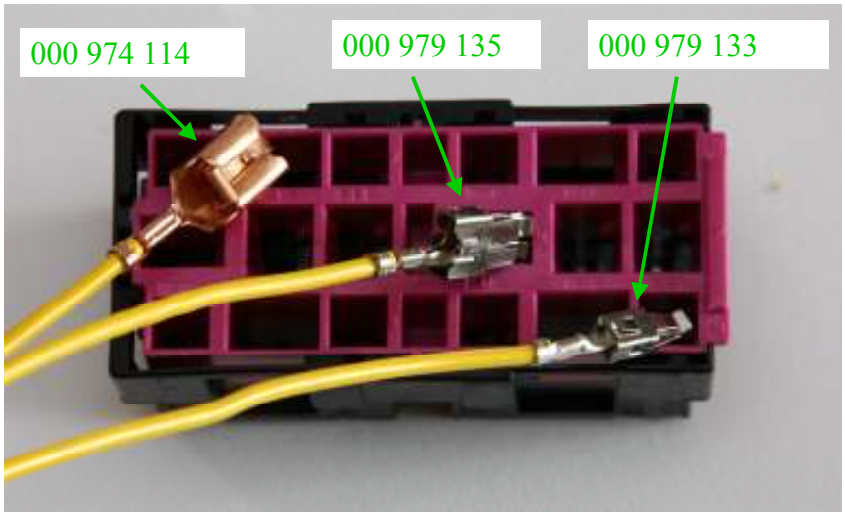
Where '?' = 1 for Telephone only, 2 for Radio/Nav only and 5 for Radio/Nav, Telephone and Voice Recognition.

You can use a '616' with a Tiptronic wheel, the multi-function buttons will work, the Tiptronic ones will not. You can also use a '618' with a non-Tiptronic wheel. VAG Com will show some faults, but the controller will still process the signals from the steering wheel.

3.13 MFSW Controller Mounting

The controller has 18 pins, of which only a maximum of 12 are used. It is mounted on a dual relay plate that does not come with any contacts.

Photo 22 MFSW Controller Mounting Plate (Rear View)



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ETKA PART DESCRIPTION	PART NUMBER	QUANTITY
Dual Relay plate	4A0 937 529	1

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MFSW Controller Mounting Plate Wiring and Contact sizes.

PIN	SIZE MM	616 (NO TIP)	618 (TIP)	FACTORY FIT WIRE COLOUR	WIRE SIZE	FROM/TO	FUNCTION
1	2.8	Yes	Yes	Orange/brown	0.35	T32c/6	CAN bus low
2	4.8	Yes	Yes	Brown	0.35	To Ground	
3	2.8	Yes	Yes	Orange/violet	0.35	T32c/5	CAN bus high
4	6.3	No	No	-	-	-	Spare
5	4.8	No	No	-	-	-	Spare
6	6.3	Yes	Yes	Green/blue	0.35	T16a/15 via A159	Data Link Connector
7	2.8	No	Yes	Violet/red	0.35	T10am/4	Tiptronic High
8	4.8	No	No	-	-	-	Spare
9	2.8	No	No	-	-	-	Spare
10	2.8	Yes	Yes	Brown	0.5	To Ground	
11	4.8	No	Yes	Violet/blue	0.35	T10am/5	Tiptronic Low
12	2.8	Yes	Yes	Black	0.35	From +15 supply	Accessory
13	6.3	Yes	Yes	Red	0.5	From +30 supply	Always on
14	4.8	No	No	-	-	-	Spare
15	6.3	Yes	Yes	Grey/blue	0.35	T32/20	Illumination ‘on’ signal
16	2.8	No	No	-	-	-	Spare
17	4.8	*	*	Black/violet	0.35	Drivers heated seat adjust switch pin 4	Switches rim heat on.
18	2.8	Yes	Yes	Red/yellow	0.5	T5d/1	MFSW Data bus

* Only required for heated wheel functionality.

The required repair wires are:

PART NUMBER	WIRE SIZE	CONTACT SIZE	QUANTITY FOR ‘616’	QUANTITY FOR ‘618’
000 979 133	1.0 mm	2.8 mm	5 contacts, 3 wires	6 contacts, 3 wires
000 979 135	1.0 mm	4.8 mm	2 contacts, 1 wire (1 contact, 1 wire if not heated)	3 contacts, 2 wires (2 contacts, 1 wire if not heated)
000 979 114	1.0 mm	6.3 mm	3 contacts, 2 wires	3 contacts, 2 wires

Each repair wire provides two identical contacts.

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4 Interfaces

There is one MFSW internal interface and ten vehicle ones to consider. These are

1. Wheel to Controller (Internal)
2. Air Bag and horn
3. ESP
4. Power supply
5. Fusing
6. Ground Returns
7. On Board Diagnostics (OBD) data link,
8. Drivers heat adjust switch
9. Infotainment CAN bus
10. 'Lights on'
11. Tiptronic Gearbox

4.1 Wheel to Controller (Internal I/F)

This Local Interconnect Network (LIN) bus is the slow speed data link used between the steering wheel electronics and the MFSW controller. It is a single wire bus operating at 20 kilobits/second and using vehicle ground for the return. As a consequence it lacks the noise immunity of a CAN Bus, but in this application that does not matter. It is a master/slave arrangement – the master initiates all transactions. It is capable of transmitting about 200 message sequences per second.

4.2 Air Bag and horn

The air bag and horn connect to the steering wheel side of the slip ring unit using a harness that comes supplied with the steering wheel. This is just plug and play. The stationary connection from the rear of the slip rings to the rest of the vehicle is made via a connector called T5d. See section 3.11.2 above. This is not plug and play. It is necessary to cut a repair wire in half and insert the contact into the empty pin 1 slot on connector T5d. This extra wire is used to connect the data bus from the steering wheel integral electronic module to the '616' or '618' Multifunction Steering Wheel Controller - J453 on the wiring diagrams. No changes are required to the horn circuit carried on T5d/2 and T5d/3 or to the air bag igniter circuit carried on T5d/4 and T5d/5.

4.3 ESP

This is plug and play. You simply plug the six-pole connector from the old slip ring unit into the new slip ring unit.

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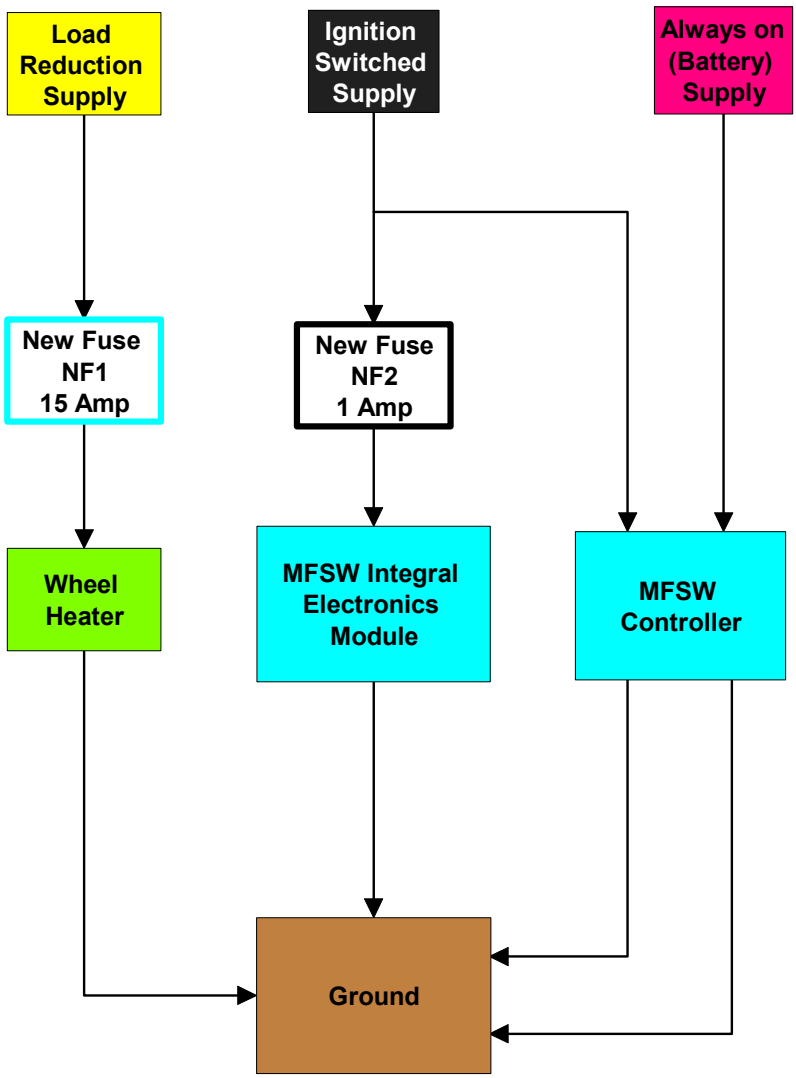
4.4 Power Supply

Figure 2 Block Schematic of Power Supply



Three different varieties of power supply are required. These are 'Always on', 'Ignition Switched' and 'Load Reduction'. Audi designates these supplies on the wiring diagrams as '30' for 'Always on', '15' for 'Ignition Switched' and 'X' for 'Load Reduction'. The load reduction supply circuit is only powered up when the ignition switch is in the 'run' position. There is no power on it with the ignition off, or when the starter is cranking the engine.

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Conveniently, two of these supplies are available and clearly labelled on a bus bar situated just behind the driver's lower storage panel. The stud labelled '75X' is the load reduction circuit and studs labelled '30' are the always-on supply.

Photo 23 Bus Bars

The ignition switched supply is a little trickier to access. It is available on a 4mm^2 black wire on pin 6 of the ignition switch. The wiring diagrams indicate it is available on the back of the fuse panel using the common run to fuses 5, 6, 7 and 31. In practice, it will be much easier to use 75X. This supply will be split to feed both the new MFSW controller and the new 1 amp fuse for the steering wheel electronic module.

4.5 Fusing

4.5.1 MFSW internal Electronics

Photo 24 Fuse, holder and terminals

These electronics will be protected by a new one-amp fuse (NF2) that will be housed in position 'C' (extreme right) on the micro-central relay panel. The fuse holder, wired fuse contacts and the fuse has to be provided. This fuse is fed by the +15 (ignition switched) supply available on the bus bar behind the drivers kick panel.

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Photo 25 Fuse location

ETKA PART DESCRIPTION	PART NUMBER	QUANTITY
Fuse holder (flat fuse, 19/2x5)	4B0 937 530	1
Flat fuse (19/2x5) 1 amp	017 131 19	1
1 mm pre-wired fuse terminals	000 979 135	2

4.5.2 MFSW Heated Rim

For a true OEM installation the rim heater is protected by fuse 27, 15 amps, housed in the fuse box. This fuse protects several other already existing circuits. However I am intending to install a separate fuse.

I measured the cold resistance of the wheel-heating element. It was 1.9 ohms. Assuming a supply voltage of about 13.6 volts, this gives a start up current of just over 7 amps and a heat output of about 100 watts. It will fall as the element heats up.

The feed to this new 15-amp fuse comes from X75, the load reduction circuit. I have suitable mounting points under the 8 way fuse holder to take an Audi fuse holder. The disadvantage is that if the fuse blows, the driver storage panel has to be removed to get at it. A more convenient way (thanks, Ted) would be to mount a new fuse holder above the Factory fuse box, so access is available from the driver side end of the dashboard. I decided to be OEM ish!

I did look at fitting additional fuse contacts in the fuse box. These appear to be only available as a complete set of fuse contact bridges, are very expensive and probably quite a lot of trouble to fit.

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ETKA PART DESCRIPTION	PART NUMBER	QUANTITY
Fuse holder (flat fuse, 19/2x5)	4B0 937 530	1
Flat fuse (19/2x5) 15 amp	01 713 112	1
Flat fuse (19/2x5) 10 amp	017 131 11	1 (alternative)
Repair wire, 2.5mm^2 x 4.8	000 979 227	2

4.5.3 MFSW Controller

This is fed directly from the +30 (always on) and the +15 (ignition switched accessory) 12 volt supply. There is no fuse on either feed.

4.6 Ground Return

Photo 26 Typical Ground Stud

There are numerous studs that provide for the normal ground return. I would simply use the most convenient. Note that it is better to connect each electronics unit directly to ground, rather than running a ground return daisy chain.

4.7 Data Link

The new MFSW controller would need to be connected to the On Board Diagnostics port. The easiest way seems to be to run a cable back directly to T16a/15, which is the relevant pin on the OBD port connector.

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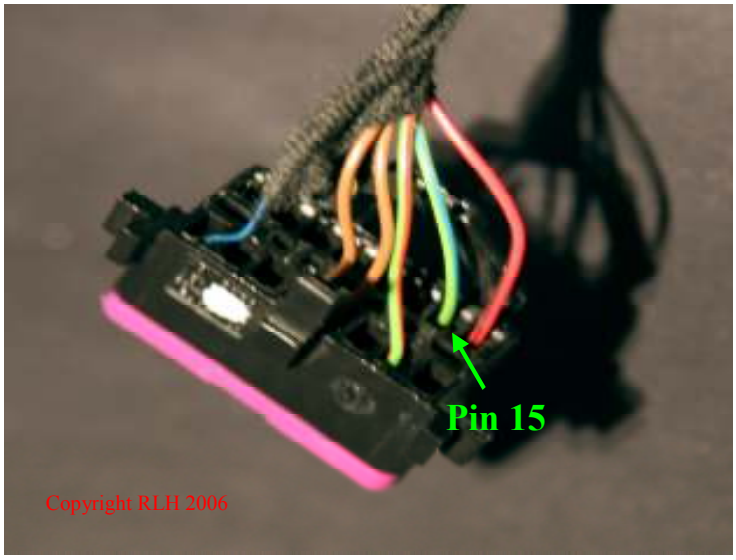
Photo 27 DLC pin 15



4.8 Drivers Heated Seat Switch

The drivers heated seat adjust switch is the same part number regardless of whether or not a heated wheel is fitted. Consequently Pin 17 on MFSW controller has only to be to be connected to pin 4 on drivers heated seat adjust switch, and for this a repair wire, part 000 979 227 has to be inserted into the switch back plate.

4.9 Infotainment CAN bus

There is more than one CAN bus in a 2002 or later model year A6 or allroad and on the C5 platform S6 and RS6. They run at different speeds and connect different controllers. We are concerned with the one that connects the MFSW controller to equipment that can be remote controlled from the steering wheel. Examples are a Symphony 2 radio or a RNS-E navigation system or the Audi telephone system. Symphony 1 did not use CAN bus for remote control and before about mid 2001 A6's did not have an infotainment can bus. However, if the instrument cluster is CAN enabled, it is possible to add one, and you may well have done this for your RNS-E installation. You can easily tell if your cluster is CAN enabled – you have a digital clock, rather than and analogue one.

CAN stands for Controller Area Network. A CAN bus is a form of data network that can be used to connect what are essentially small computers – the microprocessor based controllers of various systems in the car that need to communicate with each other. Cars are rather harsh electrical environments, and the CAN bus is a robust transport mechanism for getting data from one controller to another. Information is transmitted along the bus as packets of data, using a defined data structure. If several controllers transmit at the same time the CAN bus protocols has a mechanism for

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resolving the conflict. On Ethernet conflicts cause the two contending messages to be destroyed and subsequently each controller resends after a random interval, hopefully avoiding a clash this time. This is not an event orientated transmission protocol and the CAN bus uses a different contention algorithm so that one of the contending controllers has priority.

The type of can bus we are dealing with here has two wires. These are CAN high and CAN low. You will sometimes see these as CAN + and CAN -. To minimise noise effects the data signals are transmitted as the voltage differences between CAN high and CAN low. These wires are isolated from the car body and twisted together. This way they both pick up roughly the same amount of noise, it tends to be in phase and the CAN interface circuits in the controller can cancel it out. The bus is immune to ground noise in the vehicle. Depending on the differential transmitter/receiver circuitry in each controller, the bus may continue to work with one line disconnected, but the important noise immunity will have been lost.

There is a good write up about all this at:
http://www.embedded.com/shared/printableArticle.jhtml?articleID=13000304

By computer standards, CAN buses are not very fast. The maximum specified speed is one million bits per second. Audi run the Engine/Gearbox management CAN bus at this speed. I believe the infotainment bus runs at half this. This is useful. Because of its higher speed, much more care has to be taken with interfacing to the engine management CAN bus, and it has to be properly terminated. The Infotainment CAN bus is more forgiving, and is not safety critical. However it would be sensible to follow the general layout given in the CAN-bus wiring diagrams.

The simplest place to link the MFSW controller to the infotainment CAN bus is via the CAN High and CAN Low leads in the RNS-E plug and play adapter- especially if they were extended before installation – which is what I did. However, if the RNS-E plug and play adapter was recovered – because you want to put the radio back – you would lose the CAN bus interface for the Multi-Function Steering Wheel. Because of this I decided to use T32c/5 (CAN High) and T32c/6 (CAN low). T32 is the grey connector behind the instrument cluster. Details of how to access these can be found in Ted Basile's excellent RNS-E install PDF available in the download section of NSX-JR's site. Or use Lee Hicks's one! There is an added advantage in that the 'Lights on' signal can also be picked up behind the cluster and the three wires combined in one harness.

4.10 'Lights On'

This signal is available on T32/20, the blue connector behind the cluster.

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4.11 Gearbox Control

For both Tiptronic and conventional automatic gearboxes two signals have to be connected from the new MFSW controller to the existing Transmission Control Module. These signals are 'Tip High' and 'Tip Low'. It looks as if these signals are simply switched grounds. The real trick however is to get them where they are needed!

4.11.1 Tiptronic controls on old wheel

If you already have a Tiptronic control steering wheel, and are upgrading to MFSW and Tiptronic remote controls then there should be an easy solution. You would link the Tip High and Tip Low outputs from your new MFSW controller to the Factory Tiptronic control wires. Tip high can go to connector T5h/1 or to T17m/12. Tip Low goes to T5h/3 and also to T17m/14. Connector T5 is the black one behind the slip ring unit and T17m is a blue one behind the lower right 'A' pillar trim panel for left hand drive.

Photo 28 Typical T17m (Note: not wired for Tiptronic)

4.11.2 No Tiptronic Controls on old wheel

The factory fit wiring runs and colour scheme depend on which gearbox you have. They run from the multifunction controller (J453) to either connector T10m or connector T17m where they split and then run on to the gearbox controller (J217) and to the connector T10am on the gearbox selector switch. The wires are 0.35 mm^2 cross section.

T10m is blue and housed in the connector station under the electronics box in the plenum chamber. T17m is also blue, but housed in the connector station behind the lower right 'A' pillar trim. The colour of T10am is not given. J217, the gearbox control unit, is located under the carpet in the right front foot well.

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SIGNAL	COLOUR	SOURCE	INTER-MEDIATE	FINAL 1	FINAL 2
Tip High	Purple/red	J453/7	T10m/9	J217/12	T10am/4
Tip Low	Purple/blue	J453/11	T10m/10	J217/14	T10am/5

There are therefore four places we might consider connecting the wires:-

- As Audi do, at T10m
- At the Transmission Control Module (TCM)
- Tap onto the wiring between T10m and TCM
- At the Tiptronic Selector

T10m is difficult to get to. Not only is a fair amount of dismantling required, it is also necessary to disconnect the Engine Control Module. There are several steps that have to be taken to recode this if it is disconnected.

J217 is not in an easy place to work. The problem is the carpet that is difficult to get out of the way, particularly so on a RHD vehicle where it is shaped around the foot pedals. The connections are also different depending on the gearbox type.

Removing the drivers storage trim on RHD vehicle and the lower 'A' pillar trim shows that the harness carrying the Tiptronic selection leads is not readily visible, never mind accessible.

That leaves making the connection at the Tiptronic Selector. This also has the advantage that the pin numbering on T10am is consistent, regardless of the gearbox type.

To really clinch the argument there is an excellent article by Hervé about how to do this published on Audi World in 2002 in the 'internal' part of the technical section. See:

http://www.audiworld.com/tech/int38.shtml

Note that Hervé used three wires to connect to the Tiptronic switch. This was because he was retrofitting a Tiptronic only steering wheel. We will only need two wires, and they will run direct to the MFSW controller.

In the prototype vehicle it would have been possible to do this without removing the selector knob and the metal selector gate trim.

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5 Wiring Runs

5.1 UK Supplier

It is not viable to implement the full ex-factory harnesses. This retrofit has to be done as an overlay on the existing wiring. Consequently you would have to make these harnesses up yourself. They are not available from Audi, and a 'plug and play' solution is not really viable as you have to make a few wire taps.

In the UK I recommend Vehicle Wiring Products at http://www.vehicle-wiring-products.co.uk/ for their range of thinwall cables and other products. They carry a wide range of colour coded cables, which they sell in multiples of 1 metre. By using their 1.0 mm^2 thinwall cable it is possible to reproduce much of the Audi wiring colour scheme. Get their catalogue and look through it. I will largely be using 1.0 mm^2 thin wall cable, as that is available in a wide range of main colour/trace colour combinations. It is ok to use cable a bit thicker than Audi specify, but not to go thinner. You can also try Maplin. Radio Spares also sell this, but mainly in 100 metre rolls.

Photo 29 Vehicle Wiring Products Catalogue

(Reproduced with permission)

I recommend using cloth harness tape rather than PVC tape to wrap the wires to form harnesses. It's more flexible and gives that OEM look and feel. I also believe Ted Basile has had great success with hockey stick tape, or you can order the real OEM fabric tape from Kufatec in Germany.

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5.2 Rest of World Suppliers

Following a little prompting from Ted I started looking at what was available outside the UK. I had thought that Radio Shack in the States would stock a similar range of "Hook Up" wiring, but that is not the case. This is an interesting challenge, because it is important that you can easily differentiate which wire goes where when installing.

5.3 Label Cable

There are several ways of doing this. You can buy laminated labels that you mark up and attach to each end of the various wires. You can label them with my colour scheme or give the connector pin terminations or just number them in accordance with the tables that follow. You can also purchase clip on or stick on cable numbers that enable you to keep track of what goes where. I have used colour-coded wires and stick on numbers.

Another method, which I have used with great success before is to generate labels using a word processor, print them out and attach to the cable using transparent heat shrink tubing. I have provided a 'Cable Label Table' ☺ in the appendix to help you do this if you choose.

5.4 Cable assembly

You will have to fasten Audi repair wires on to the ends of the cables you have purchased to make up the harnesses. You can either crimp or solder. The aero industry regards crimping as more reliable but I find soldering makes a more compact joint.

5.4.1 Crimping

If you crimp, be aware that Audi recommends a very high-class and expensive adhesive filled heat shrink crimp connector. If you solder, I strongly recommend you encase each joint in its own heat shrink enclosure rather than using tape – heat shrink tubing is readily available. The adhesive filled version is more robust, but also more rigid. See the Audi wiring repair guide.

Use the correct size (i.e. colour) crimp connector for the wires you are joining. In general this means the red ones, unless it is thicker cable on a power feed, where you might want to use a blue connector. If using cables smaller than 0.5 mm^2 (AWG 20) then strip twice the length required and fold the stripped end of the wire over to get the right diameter and length for the connector before crimping. There is plenty of guidance about how to crimp on the Internet.

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Photo 30 Crimp connector and tool

5.4.2 Soldering

Soldering is not difficult. My hands can shake a bit, and I have developed a way of dealing with this when joining wiring. I buy some un-insulated crimp connectors the right size for the wires I am joining – any sort will do as I break the spade or ring off the ends, leaving me with a short length of tube. I slip a piece of heat shrink over one wire, strip a small length of each wire, place both wires in my small tube and crimp. They then stay together while I complete the joint with solder. I the slip the heat shrink tube over the joint, shrink it down with a hot air gun and I have a compact and very professional looking high quality joint.

5.5 Cable Runs

Their smallest size cable stocked by Vehicle Wiring Products is 0.5mm², not 0.35 mm² as used by Audi for signal wires. I use "thinwall" which has a higher specification and thinner insulation. Where it is not possible to exactly match the OEM cable, I have specified a suitable alternative. There are notes below each cable table (ah, alliteration!).

At Ted's suggestion, I have also given the equivalent wire sizes in American Wire Gauge. Audi's 0.35 mm² is about AWG 22, Audi 0.5 mm² is about AWG 20 and Audi 1.0 mm² is AWG 17. You might want to go up a size to AWG 16, rather than down to AWG 18, but this is really only necessary on the wheel heater circuits, AWG 18 will be fine elsewhere instead of 1.0 mm². There is a conversion table in the appendix.

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Photo 31 The Thinwall Cables

Where wring relates to both the '616' and '618' MFSW controllers, I have used the generic identification 'J453'. Where wiring is specific to one controller, I have used the module number, either '616' for no Tiptronic controls, or '618' if Tiptronic functionality is required.

I have given each wire in the following tables a reference number, and this can be used to identify each wire as well as the colour scheme. Even if your wires are all the same colour, just label each one with its reference number at each end. These reference numbers are used in part 2 (as well as my particular colour coding scheme) to identify the wires in each sub-harness.

5.5.1 Load Reduction Power to New Fuse 1 (NF1)

There is one wire. NF1 will be 15 amps.

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#1	Black/yellow	2.0/14	Black/Yellow	2.0	75X Stud	NF1/1	1 ft or 30 cm

- Exact match to take off point. 2mm feed to fuse requires fuse contacts with 2mm tails.

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5.5.2 NF1 to Steering Wheel Heater

There is one wire

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#2	Black/Yellow	1.0/18	Black/yellow	1.0	NF1/2	T2bg/1	60” or 150 cm

- Exact match. Fuse contact NF1/2 will be specified with 2mm tail and then downsized to cable run.

5.5.3 Steering Wheel Heater Power to Ground

There is one wire

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#3	Brown	1.0/18	Brown	1.0	T2bg/2 & T5h/3	Vehicle Ground	60” or 150 cm

- Exact match

5.5.4 Steering Wheel to J453 Controller Data Bus

There is a single wire

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#4	Red/Yellow	0.5/20	Red/yellow	1.0	T5d/1	J453/18	60” or 150 cm

- Exact Match

5.5.5 ‘Ignition on’ Power to New Wheel Electronics fuse NF2

There is one wire

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#5	Black/red	1.0/18	Black/red	1.0	Ig Acc	NF2/1	24” or 60 cm

- Matches existing cable run to fuses 5, 6, 7 and 31 that is an Ignition switched accessory feed. (X75 stud carries Load reduction, not accessory supply).

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5.5.6 Fuse NF2 to Steering Wheel Module

There is one wire

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#6	Black/red	0.35/22	Black/red	1.0	NF/2	T5h/2	60” or 150 cm

- Black/red is not available from VWP in 0.5mm. Better to keep colour coding.

5.5.7 MFSW (J453) Controller to Infotainment CAN bus

There are two twisted-wires.

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#7	Orange/brown	0.35/22	Orange	0.5	J453/1	T32c/6	24” or 60 cm each
#8	Orange/Violet	0.35/22	Pink	0.5	J453/3	T32c/5	

- Two tone is not available from VWP in 0.5mm
- More important to use thinner cable behind cluster to ease installation.
- Cables twisted so readily identified.
- Violet not available in 0.5mm
- T32c is the grey connector behind the instrument cluster.
- T32c/5 is CAN high, T32c/6 is CAN low.
- Twisted wire pair is easily made up with a vice and a slow running cordless drill.
- There is a useful alternative to making up your own twisted pair cable run, and that is to use one of the four twisted pairs in a length of Cat 5 Ethernet cable.

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5.5.8 Power and Ground return to MFSW (J453) Controller

There are four wires

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#9	Red	0.5/20	Yellow	0.5	K30 stud	J453/13	12" or 30 cm each
#10	Black	0.35/22	Yellow	0.5	Fuse 5, 6, 7 & 31 common.	J453/12	
#11	Brown	0.35/22	Yellow	0.5	J453/2	Ground	
#12	Brown	0.5/20	Yellow	0.5	J453/10	Ground	

- Black & Brown wire slightly oversized, but will not matter, or be noticed.
- Appropriate repair wires used to minimise joints.

5.5.9 MFSW (J453) Controller to Data Link Connector

There is a single wire

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#13	Green/blue	0.35/22	Green	0.5	J453/6	T16a/15	20" or 50 cm

- Two tone is not available in 0.5mm. I have stayed with a small diameter to ease connection to the T16a connector, which is similar to a 'D' type socket. A blue tape can be wound round the cable if required to identify it clearly.

5.5.10 MFSW (618) Controller to Tiptronic Switch

There are two wires

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#14	Violet/red	0.35/22	Slate	0.5	618/7	T10am/4	72" or 180 cm each
#15	Violet/blue	0.35/22	Light green	0.5	618/11	T10am/5	

- Two tone is not available in 0.5mm. I have stayed with a small diameter to ease connection to wires on connector T10am by the selector switch.
- Tip High is on T10am/4, Tip Low is on T10am/5
- Proposed colours were 'in stock'!

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5.5.11 'Lights On' to MFSW (J453) Controller

There is a single wire

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#16	Grey/blue	0.35/22	Slate	0.5	T32/20	J453/15	2" or 60 cm

- Two tone colours not available in 0.5mm. It is more important to use a thin flexible wire to access T32/20 behind the instrument housing.
- T32 is the blue connector.

5.5.12 Drivers Heat Adjust Switch to MSFW (J453) Controller

There is a single wire.

REF	FACTORY WIRE COLOUR	FACTORY WIRE SIZE MM²/AWG	PROPOSED WIRE COLOUR	PROPOSED WIRE SIZE	FROM	TO	INSTALLED LENGTH
#17	Black/violet	0.5/20	Purple	1.0	DHAS/4	J453/17	72" or 180 cm

- Violet is not available in VWP wiring scheme. 1.0mm cable used to stay close to OEM colour scheme. Contact behind the drivers heat adjust switch will have a 1.0mm tail at any rate.

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6 Harness

The complete MFSW installation harness can be built up before it is installed in the car. This has the advantage that it can be done in comfort and checked for correct continuity before installing. It will also reduce the time the vehicle is off road. It is not plug and play because a number of wiretaps have to be made to the existing vehicle harness.

You will need to tap into the following:

WHERE	ON WHAT	WHY
Tiptronic Selector #1	T10am/4	Tip High
Tiptronic Selector #2	T10am/5	Tip Low
Cluster #1	T32/20	'Lights on'
Cluster #2	T32c/5	CAN High
Cluster #3	T32c/6	CAN Low
Data Link	T16a/15	'K' line

The full harness can be built up as you go by treating it as a series of sub-harnesses that are described below. The sub-harnesses are then assembled into two harnesses with most of the wiring around the controller dual relay mounting plate.

Each sub-harness is presented as a table giving the components followed by a layout drawing. I recommend building up a single, complete harness, and then installing it in the vehicle.

The lengths given include the repair wires at the ends.

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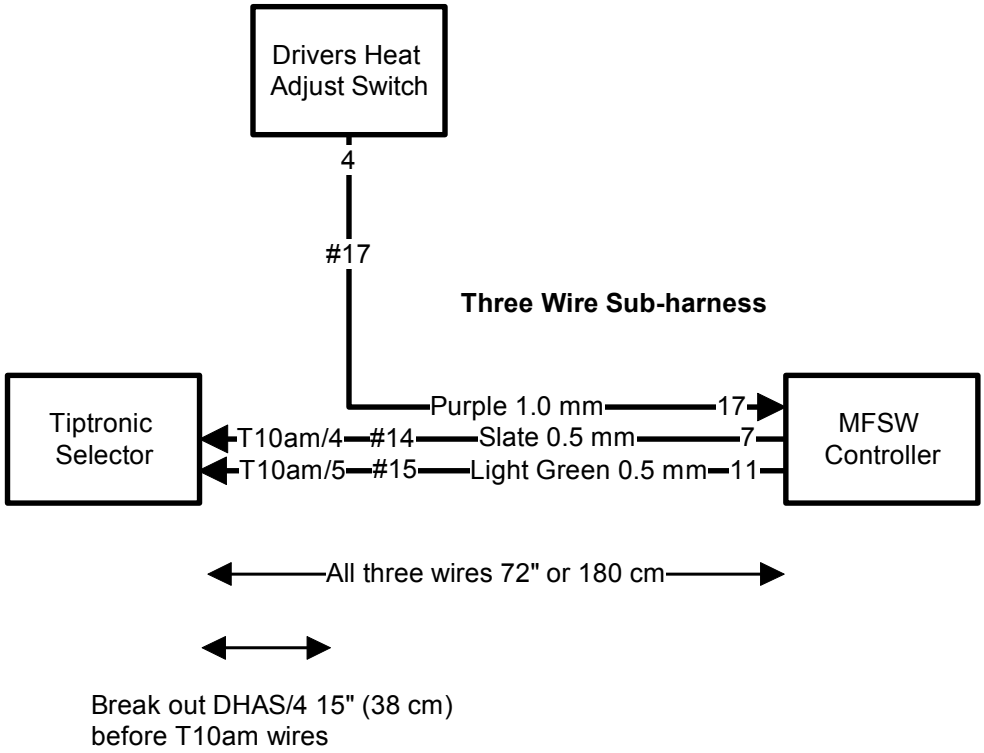
6.1 Tiptronic and Heat Switch Sub-harness

DESIGNATION	DESCRIPTION	PART NO. AND LENGTH
MFSW Controller	Dual Mounting Plate	4A0 937 529
Drivers Heat Adjust Switch	Repair Wire	000 979 135
Controller Mounting pin 7	Repair Wire	000 979 133
Controller Mounting pin 11	Repair Wire	000 979 135
Controller Mounting pin 17	Repair Wire	000 979 135
#17, Purple wire	1.00 mm AWG 18	72” or 180 cm
#14, Slate wire	0.5 mm AWG 20	72” or 180 cm
#15, Light Green wire	0.5 mm AWG 20	72” or 180 cm
Heat shrink tubing	To fit	-

Figure 3 Tiptronic and Heat Switch Sub-harness



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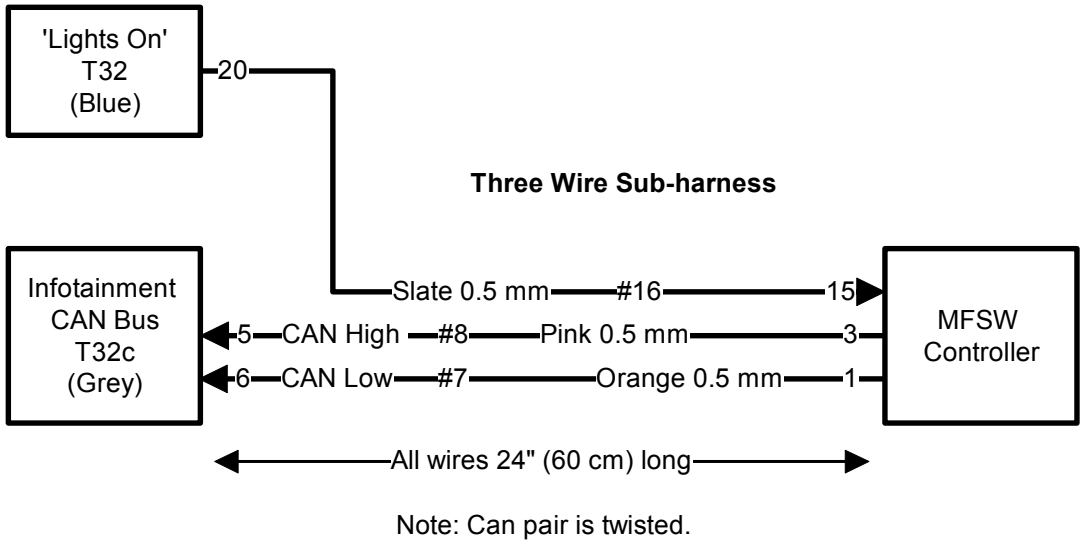
6.2 Cluster Sub-harness

DESIGNATION	DESCRIPTION	PART NO. AND LENGTH
MFSW Controller	Dual Mounting Plate	4A0 937 529
T32/20	Wire Tap	
T32c/5	Wire Tap	
T32c/6	Wire Tap	
Controller Mounting pin 1	Repair Wire	000 979 133
Controller Mounting pin 3	Repair Wire	000 979 133
Controller Mounting pin 15	Repair Wire	000 979 114
#16, Slate wire	0.5 mm AWG 20	24” or 60 cm
#8, Pink wire	0.5 mm AWG 20	24” or 60 cm
#7, Orange wire	0.5 mm AWG 20	24” or 60 cm
Heat shrink tubing	To fit	-

Figure 4 Cluster Sub-harness



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6.3 Wheel Sub-harness

The wire lengths used here are longer than might be expected. This is to enable them to be routed well clear of the steering column by following the existing factory installed wiring looms.

DESIGNATION	DESCRIPTION	PART NO. AND LENGTH
MFSW Controller	Dual Mounting Plate	4A0 937 529
Controller Mounting pin 18	Repair Wire	000 979 133
New Fuse NF1	Housing	4B0 937 530
NF1/2 contact	Repair Wire	000 979 227
Ground Stud	5mm Crimp Eyelet	
New Fuse NF2	Housing	4B0 937 530
NF2/2 contact	Repair Wire	000 979 135
T2bg	Housing	893 971 632
T2bg/1 and T2bg/2 contacts	Repair Wires	000 979 133
T5h	Housing	4B0 973 605
T5h/2 contact	Repair Wire	000 979 018
T5h/3 contact	Repair Wire	000 979 018
T5d	Housing	Already present
T5d/1 contact	Repair Wire	000 979 018
Wire Junction	Tap or Solder	-
#2, Black/yellow wire	1.0 mm AWG 18	60” or 150 cm
#3, Brown wire	1.0 mm AWG 18	60” or 150 cm
#6, Black/red wire	1.0 mm AWG 18	60” or 150 cm
#4, Red/yellow wire	1.0 mm AWG 18	60” or 150 cm
Heat shrink tubing	To fit	-

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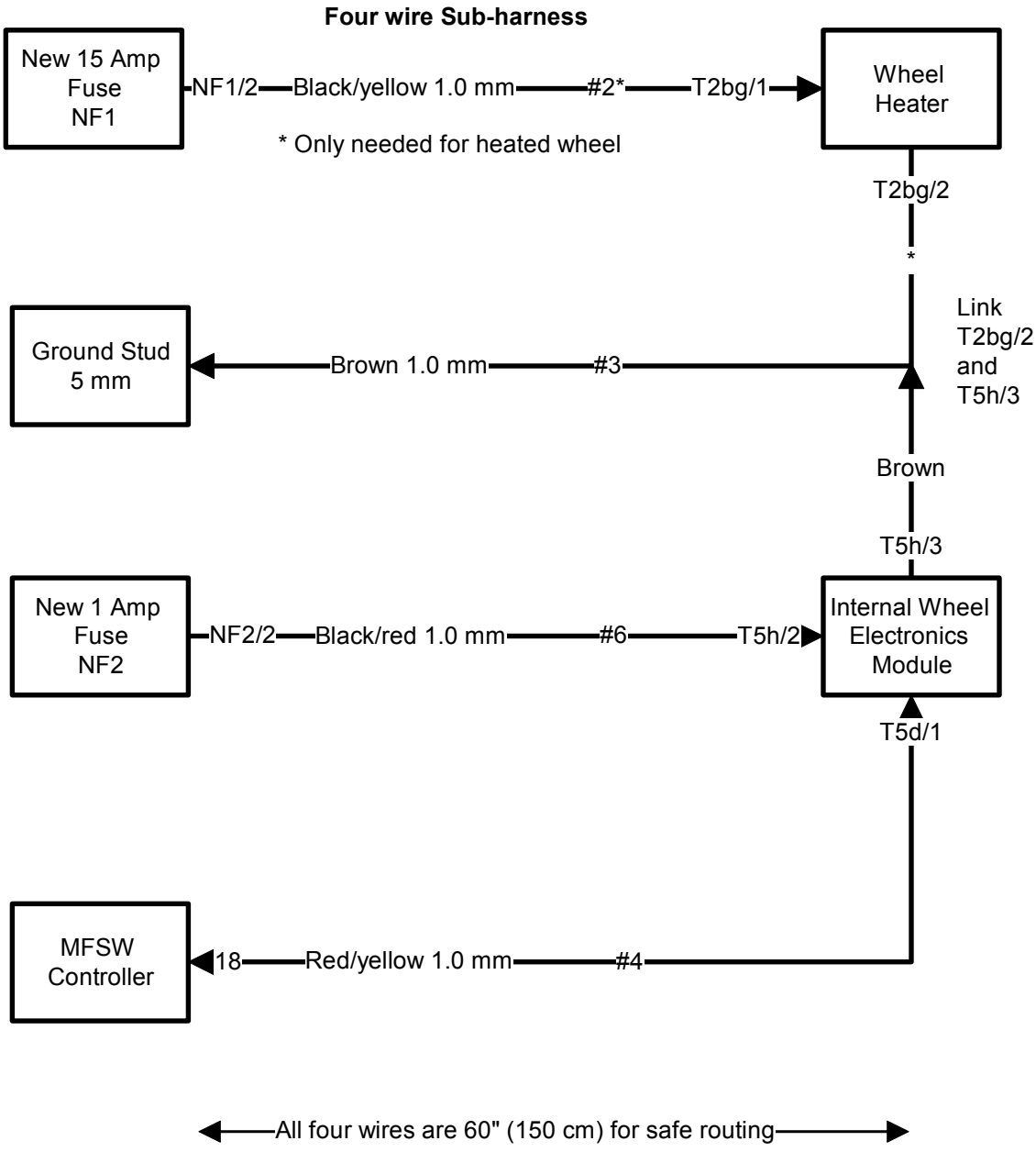
Figure 5 Wheel Sub-harness



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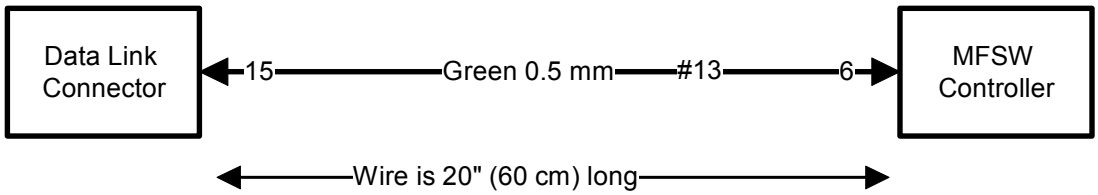
6.4 Data Link Connector (OBD) Sub-harness

DESIGNATION	DESCRIPTION	PART NO AND LENGTH
MFSW Controller	Dual Mounting Plate	4A0 937 529
Controller Mounting pin 6	Repair Wire	000 979 114
Data Link Connector pin 15	Wire Tap	
#13, Green wire	0.5 mm AWG 20	20” or 50 cm
Heat shrink tubing	To fit	-

Figure 6 Data Link Connector Sub-harness



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6.5 Controller Power and Ground Sub-harness

DESIGNATION	DESCRIPTION	PART NUMBER OR LENGTH
MFSW Controller	Dual Mounting Plate	4A0 937 529
Controller Mounting pin 2	Repair Wire	000 979 135
Controller Mounting pin10	Repair Wire	000 979 133
Controller Mounting pin12	Repair Wire	000 979 133
Controller Mounting pin13	Repair Wire	000 979 114
K30 Stud	Red 5mm crimp ring	-
Fuses 5,6,7 & 11 common	Wire Tap	-
Ground Stud	Red 5mm crimp ring	-
New Fuse NF2	Housing	4B0 937 530
NF2/1 Contact	Repair Wire	000 979 135
Wire Junction	Butt Crimp or solder	-
#9, Repair wire	0.5 mm AWG 20	12” or 30 cm
#10, Repair wire	1.0 mm AWG 18	12” or 30 cm
#11, Repair wire	0.5 mm AWG 20	12” or 30 cm
#12, Repair wire	0.5 mm AWG 20	12” or 30 cm
Heat shrink tubing	To fit	-

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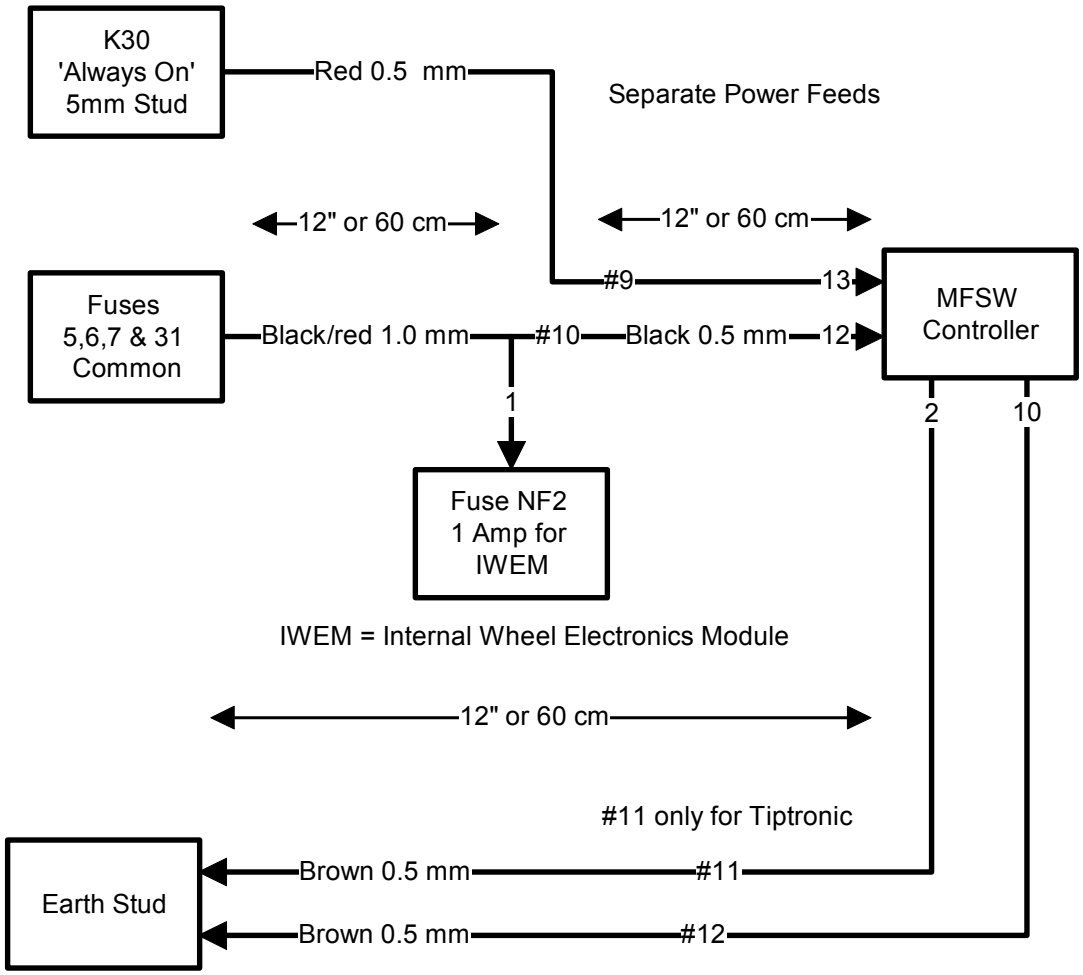
Figure 7 Controller Power and Ground Sub-harness



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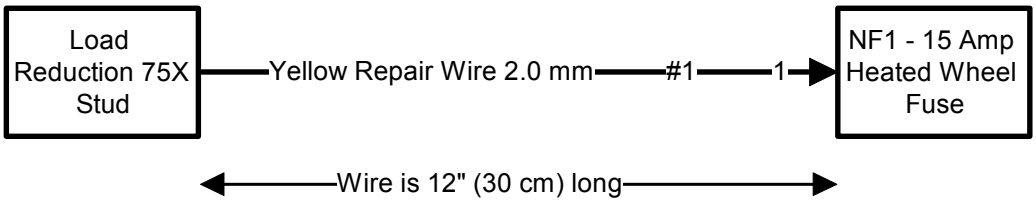
6.6 Heated Wheel Fuse Sub-harness

DESIGNATION	DESCRIPTION	PART NUMBER OR LENGTH
Load Reduction Stud	Blue 5 mm crimp ring	-
Heated Wheel Fuse (NF1)	Housing	4B0 937 530
NF1/1 contact	Repair Wire	000 979 227
#1, Black/yellow wire	2.0 mm AWG 14	12” or 30 cm
Heat shrink tubing	To fit	-

Figure 8 Heated Wheel Fuse Sub-harness



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7 Power Up

Before reconnecting the battery, carry out a full visual check of all your wiring. Better still, get some-one else to do it for you – they will need something to check against – your documentation, perhaps.

Then a continuity test can be carried out using any standard multi-meter. The better ones have a built in buzzer, which makes this that much easier.

WARNING
Do not under any circumstances check the continuity of an air bag igniter. Do not test wiring on yellow connectors. The air bag may deploy.

The air bag controller will test the air bag ignition circuit for you when you connect the battery and switch the ignition on. It will use voltages and current that will not cause deployment. A resistance or continuity check with a multi-range meter (digital or analogue) may well apply enough power to fire the igniter and deploy the air bag.

You can now reconnect your battery.

WARNING
Do not have anyone in the vehicle when you reconnect the battery after working on the airbags The air bag may deploy

Remember to connect the positive terminal first and then the negative terminal. Check for smoke. If there is any, disconnect the battery negative quickly and investigate.

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8 Telling Controllers there is an MFSW present

Having completed all the wiring, and successfully re-connected the battery, you need to tell a number of controllers that a MFSW is present. This is done using VAG Com (or a very friendly dealer!).

8.1 Multifunction Controller

See section 3.12 above.

8.2 Symphony 2 Radio

This has a five digit soft code, referenced below as ABCDE. Add the 'values if present' to give the numerical digit for each position.

POSITION	FUNCTIONALITY	VALUE IF PRESENT
A	-	Always zero
B	A8	1
B	A4 From 2002	2
B	A6	3
B	A4 Cabrio (from 2002)	4
B	TT	5
C	Amp switched off with incoming phone call	1
C	BOSE display on	2
C	Fader deactivated	4
D	SBS (Voice Recognition)	1
D	Telephone	2
D	Navigation	4
E	Multi Function Steering Wheel	1
E	CD Changer	2
E	Diversity Box	4

So, if you now have an A6 with amp switch off with incoming phone call, Bose Display, telephone, the old trunk mounted navigation, your new multi-function steering wheel, CD changer and diversity box the code would be: -

A	B	C	D	E
0	3	3	6	7

8.3 RNS-E Navigation

See: -
http://www.navplus.us/forum/viewtopic.php?t=73

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8.4 Audi Blue-tooth Telephone

See: -
http://www.navplus.us/forum/viewtopic.php?t=1362&start=0&postdays=0&postorder=asc&highlight=code

8.5 Instrument Cluster

Looking at http//:de.openobd.org/audi/a6-4b.htm it appears that if you have retrofitted the high end Drivers Information System (Colour DIS) then you would need to change the adaptation values in channel 36. This should only be the case for the D2 and B6/B7 platform. As far as I now know (thanks again, Ted!) the C5, B5 and TT platforms do not have this colour DIS upgrade option at all. In any event, if you know how to retrofit new clusters, you probably did not need to read this!

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9 Appendices

9.1 Sources Used

9.1.1 NAVPlus.US

- http://www.navplus.us/forum/viewtopic.php?t=2860 This is Proxus' summary of how to fit a B7 MFSW into a B6 Audi. It's an excellent background read, but very different from what is needed for the C5 platform A6, and there are some safety issues to think about.
- MFSW retrofit – Coding for steering sensor, abs, etc, etc, by "dunk" on April 18th 2005.

9.1.2 Audi ETKA ©

- Illustration 419-20, Steering Wheel
- Illustration 880-00, Air Bag
- Illustration 959-30, Cancelling/Slip Ring
- Illustration 972-24, Air Bag wiring Harness
- Illustration 937-20, Fuse Box

9.1.3 Bentley CD Manual © and erWin DVD ©

I have not given the sheet numbers as they differ, but they are easy to find. Note that the official Audi erWin documentation (ideal for non USA) is also available for download on a flat rate basis. This gives access to all documentation for all vehicles for one subscription. The DVD allows you to access specific information for a specific vehicle, and is slightly (!) more reasonably priced at just over 100 euros for a years access to the C5 wiring diagrams, compared with 1800 euro's for a years access to all Audi documentation for all Audi vehicles. Those of you who can use Bentley Publishers are fortunate!

- Current Flow/ Wiring Diagram, Multi-function Steering Wheel
- Current Flow/ Wiring Diagram, Steering Wheel with Tiptronic
- Current Flow/ Wiring Diagram, Heated Steering Wheel
- Current Flow/ Wiring Diagram, Automatic Transmission, Multitronic
- Current Flow/ Wiring Diagram, Standard Equipment

- Multi-function Steering Wheel, On Board Diagnostic (OBD)
- Driver's airbag unit – Removing and Installing
- Removing and Installing steering angle sensor (G85-)

- ESP login and coding tables

- Technical data: Brakes

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9.1.4 From NSX-JR

- Database of Audi connector housings and matching pins – with useful pictures.

http://www.nsxjr.com/Audipins.html

9.1.5 From Ross Tech

- Ross-Tech>Home>Products>VAG-COM>Support>Car Info & Procedures>ESP Coding
- Ross-Tech Wiki (see text above)

9.1.6 From Audi World

- Audi World Tech Article © 2002 by Hervé: Retrofitting a Tiptronic Steering Wheel on an A6 see: http://www.audiworld.com/tech/int38.shtml
- There is also an excellent article by Boston Driver on installing a Paddle Wheel See http://forums.audiworld.com/a6/msgs/547564.phtml

9.1.7 Allroad FAQ

- www.AllroadFAQ.com

9.1.8 Volkswagen Wiki

Everything you ever wanted to know about FNR-G60 Front brakes on:
vw-wi://rl/A.en-US.4B-B-B.wi::22840584.xml?xsl=2

9.2 Tools Required and Suppliers

9.2.1 Vag Com

VAG Com is required to code the multi-function steering wheel controller and to recode the braking system after the steering angle sensor has been replaced. It consists of three components, a cable, some software and a computer to run it on.

9.2.1.1 VAG Com Cable

Photo 32 VAG Com Cable

You need to get access to the real thing. It is expensive at around 250 GBP. The latest versions of VAG Com software do not support the cheap cables you see advertised, and there is good reason for this. There is specialist communications hardware in the proper Ross-Tech cable and you need to use this.

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The alternative to buying if you cannot beg or borrow one is to use the dealers VAS 5051 or VAG 1551 tools. Expect to pay for this service, and be very careful how you drive your car to the dealer. ESP will not be working properly.

9.2.1.2 VAG Com software

Photo 33 VAG Com Screen

The good news is that all updates are free. It has built in authentication, with the cable acting as a 'dongle'. Downloads and advice and support are readily available from the Ross-tech web site. Always check that you are using the latest version of the software. Ross Tech has very good documentation available. I downloaded and printed out the user guide. The software also includes a lot of help information to guide you when entering data.

9.2.1.3 Computer to run VAG Com software

Although you might not expect it, the serial port version is the better choice if you have a computer that still supports the old serial COM ports. This is because there is no need for a USB driver and as a result the timing protocols run more accurately. If you want or need to use the USB version of the cable, check the minimum computer requirements at Ross-tech. Last time I looked they recommend Windows XP and 1 GHz. The COM version runs on anything greater than 100MHz.

You need a Microsoft ® Windows environment, preferably XP with the latest service pack. See section 9.2.1.1 above for minimum specification. Apparently VAG Com will run happily on an Intel Mac platform running XP using boot camp.

9.2.2 Test Gear

A simple multi-meter is an invaluable aid for checking continuity of harnesses you have made up.

9.2.3 Spanners and things

- 8mm spanner for fuse box
- 10 mm spanner to undo battery negative terminal

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- 10 mm socket for micro central relay panel
- Inspection Lamp
- Socket set T30 Torx driver to release Air Bag.
- T25 Torx driver to remove trim behind steering wheel.
- 8mm nut spinner for trim bolts – makes things much easier.
- Putty knife to pry up Tiptronic trim.
- ½" drive Ratchet or 'T' bar along with ½" drive extension and ½" drive XZN M12 triple square (twelve-spline) drive bit. These are required to undo the bolt that holds the steering wheel on to the column.
- Good quality wire strippers. I recommend the fully automatic type.
- Wire cutters (built into strippers shown)

Photo 34 Auto Strippers

- Automotive Blue/Red/Yellow Pre-insulated terminal Crimp Tool
- 25 watt soldering iron (if you do not crimp)
- Hot air gun for heat shrink tubing
- Small craft knife to extract T32 and T32c connector pins
- Torque Wrench to tighten wheel bolt
- Radio/Nav extraction tools (four off)
- Small needle nosed pliers

9.3 Technical Skills Required for Implementation

My research suggests that this is a reasonably complex project. If you have not done anything like this before I would contemplate installing an RNS-E navigation unit first. The experience will be invaluable, and you will have a use for your multi-function wheel!

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9.4 Wire sizes and conversion

Audi specify their wiring in mm^2. The figures given above relate to the cross sectional area of the wires. This makes good sense as it linearly relates to the current carrying capacity. I've given an extract from a conversion table below for those who do not readily think in metric. Note that the current rating quoted is typical – different sources give different values as it depends on how hot the wire is allowed to become, and this is affected by the insulation used and the construction of the cable. This table does not fully match the Vehicle Wiring Products cable current ratings. It is generally better to use a slightly heavier rather than lighter cable to give less voltage drop and less heat dissipated.

AWG GAUGE	DIAMETER INCHES	CROSS SECTION MM^2	TYPICAL CURRENT RATING (AMPS)
6	0.162	13.30	100.0
7	0.144	10.56	90.0
8	0.129	8.37	70.0
9	0.114	6.63	65.0
10	0.102	5.26	55.0
11	0.091	4.17	45.0
12	0.081	3.31	40.0
13	0.072	2.63	35.0
14	0.064	2.08	32.0
15	0.057	1.65	28.0
16	0.051	1.31	22.0
17	0.045	1.04	19.0
18	0.040	0.82	16.0
19	0.036	0.65	14.0
20	0.032	0.52	11.0
21	0.029	0.41	9.0
22	0.025	0.33	7.0
23	0.023	0.26	4.7
24	0.020	0.20	3.5
25	0.018	0.16	2.7
26	0.016	0.13	2.2
27	0.014	0.10	1.7
28	0.013	0.08	1.4
29	0.011	0.06	1.2
30	0.010	0.05	0.9

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9.5 Vagparts Order

This is the order as submitted on 4th October 2006
I have used an exchange rate of £1 = $1.87 US

PART NUMBER	ETKA DESCRIPTION	UNIT COST	QTY	TOTAL £'S	TOTAL US $
8Z0 419 091BD1KT	Heated MFSW with Tip (leather - heated) Soul-Black	£346.43	1	£346.43	$647.82
8P0 880 201BP6PS	Airbag with switch for radio, phone and voice op Soul - Black	£354.22	1	£354.22	$662.39
N 907 991 01	Bolt M18x1.5x18	£1.26	1	£1.26	$2.36
N 017 13 119	1 amp fuse (19/2x5)	£0.22	2	£0.44	$0.82
N 017 13 116	5 amp fuse (19/2x5)	£0.18	2	£0.36	$0.67
N 017 13 111	10 amp fuse (19/2x5)	£0.18	2	£0.36	$0.67
N 017 13 112	15 amp fuse	£0.18	2	£0.36	$0.67
4B0 937 530	Fuse holder (19/2x5)	£1.22	3	£3.66	$6.84
000 979 135	1mm pre wired terminals	£0.92	4	£3.68	$6.88
000 979 227	2mm pre wired terminals	£0.92	2	£1.84	$3.44
1J0 959 654 AL (1J0 959 654 Q received)	Canceling ring with slip ring and steering sensor. Mult. Steering Wheel (leather) with ESP and heated	£128.70	1	£128.70	$240.70
893 971 632	Connector T2bg, black, 2 pin	£1.14	1	£1.14	$2.13
000 979 133	Repair wires for Connector T2bg - 1mm	£0.92	2	£1.84	$3.44
6E0 971 582C	Connector T5d, (yellow, 5 pin)	£15.60	1	£15.60	$29.17
111 971 941A	Audi Say ALSO USE 2 of these heat shrink connectors for the above	£0.73	2	£1.46	$2.73
4B0 973 605	Connector T5h, black, 5 pin	£2.78	1	£2.78	5.20
000 979 018	Repair wires for existing connector T5d (maybe!) and T5h	£1.81	5	£9.05	$16.92
4B0 907 487 H	Control Unit for Multifunction Steering Wheel without telephone or with preparation for telephone	£102.93	1	£102.93	$192.48
4A0 937 529	Dual Relay Plate (to mount MFSW controller)	£4.60	1	£4.60	$8.60
000 979 114	Repair wire 6.3mm contact for relay plate 1mm^2 wire	£0.92	10	£9.20	$17.20
000 979 133	Repair wire 2.8mm contact for relay plate 1mm^2 wire	£0.92	10	£9.20	$17.20
000 979 135	Repair wire 4.8mm contact for relay plate 1mm^2 wire	£0.92	10	£9.20	$17.20
Ex VAT Total				£1,018.31	approx. $1900
Value Added Tax	(VAT is payable by EU residents only)			£178.20	
TOTAL				£1,196.51	

Note: There are far too many repair wires ordered, and you do not need T5d.

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9.6 Vehicle Wiring Products Order

ITEM DESCRIPTION	SIZE / COLOUR	REF	QTY	COST (EX VAT)
0.5mm^2 Thinwall cable	Orange	11	2M	£0.42
ditto	Pink	11	2M	£0.42
ditto	Red	11	1M	£0.21
ditto	Black	11	1M	£0.21
ditto	Brown	11	1M	£0.21
ditto	Green	11	3M	£0.63
ditto	Slate	11	3M	£0.63
1.0mm^2 Thinwall cable	Brown	16	1M	£0.26
ditto	Black/yellow	16	1M	£0.26
ditto	Black/red	16	2M	£0.52
ditto	Black/purple	16	1M	£0.26
ditto	Red/yellow	16	1M	£0.26
2.0mm^2 Thinwall cable	Black/yellow	25	1M	£0.36
Cloth Tape, adhesive	Black	3380	2 rolls	£4.94
Cable Ties, 4”	Black	CT100B	100	£1.00
Heatseal Pre-ins ring crimp	Red, 6 mm	RR6H	6	£2.52
Heatseal Pre-ins ring crimp	Blue, 6 mm	BR6H	1	£0.42
Cable Labels	-	WM1J	1	£0.73

- Cable order multiple is per metre; cable ties come in 100’s.

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9.7 Cable Label Table ☺

To use cut out each row, cut down centre and attach along the length at each end of appropriate cable using transparent heat shrink tubing. This tubing appears translucent, but goes clear on heating. The row height is approx 1/5th inch (4.5mm), which is the circumference of the smallest cable you will be using.

Ref	From	To	Ref
#1	75X	NF1/1	#1
#2	NF1/2	T2bg/1	#2
#3	T2bg/2	Ground	#3
#4	T5d/1	J453/18	#4
#5	Ig Acc	NF2/1	#5
#6	NF2/2	T5h2	#6
#7	J453/1	T32c/6	#7
#8	J453/3	T32c/5	#8
#9	K30	J453/13	#9
#10	Ig Acc	J453/12	#10
#11	J453/2	Ground	#11
#12	J453/10	Ground	#12
#13	J453/6	T16a/15	#13
#14	J453/7	T10am/4	#14
#15	J453/11	T10am/5	#15
#16	T32/20	J453/15	#16
#17	DHAS/4	J453/17	#17

Part 2 – A Photographic Implementation Record

- Follows for late December 2006

END OF DOCUMENT

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