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The USRP E310 offers a portable stand-alone SDR platform designed for field deployment. The flexible 2x2 MIMO AD9361 transceiver from Analog Devices provides up to 56 MHz of instantaneous bandwidth and spans frequencies from 70 MHz ? 6 GHz to cover multiple bands of interest.

- Xilinx Zynq 7020 SoC: 7 Series FPGA with ARM Cortex A9 667 MHz dual-core processor
- Analog Devices AD9361 RFIC direct-conversion transceiver
- Frequency range: 70 MHz - 6 GHz
- Up to 56 MHz of instantaneous bandwidth
- 2x2 MIMO transceiver
- Up to 10 MS/s sample data transfer rate to ARM processor
- RX, TX filter banks
- Integrated GPS receiver
- 9-axis inertial measurement unit
- RF Network on Chip (RFNoC?) FPGA development framework support



- Battery Operated
- Xilinx Zynq 7020 SoC: 7 Series FPGA with ARM Cortex A9 866 MHz dual-core processor
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The USRP E310 MIMO XCVR daughterboard features an integrated MIMO capable RF frontend.

The RF frontend has individually tunable receive and transmit chains. Both transmit and receive can be used in a MIMO configuration. For the MIMO case, both receive frontends share the RX LO, and both transmit frontends share the TX LO. Each LO is tunable between 50 MHz and 6 GHz.

All frontends have individual analog gain controls. The receive frontends have 76 dB of available gain; and the transmit frontends have 89.5 dB of available gain. Gain settings are application specific, but it is recommended that users consider using at least half of the available gain to get reasonable dynamic range.

The frontends provide a lo-locked sensor that can be queried through the UHD API.

The transmit and receive filter banks uses switches to select between the available filters. These paths are also dependent on the antenna switch settings. Incorrectly setting the switches generally results in attenuated input / output power. Receive filters are band pass (series high & low pass filters), transmit filters are low pass.

Source code related to controlling the filter band and antenna switches resides in `e300_impl.c`. Specifically, refer to methods `e300_impl::_update_bandssel`, `e300_impl::_update_atrs`, `e300_impl::_update_gpio`, and `e300_impl::_update_enables`. Generally, these methods set the switches depending on the state of transmit and receive streams.

The following sections provide switch setting tables for antenna and filter selection for frontends A & B receive and transmit paths. For further details refer to the schematics.

*Note: X = don't care, T = If full duplex, set bits according to transmit table, otherwise don't care. Filter range A ? B will be selected if  $A \leq \text{freq} < B$ .*

#### Receive

RX Port	RX Filter (MHz)	VCTXR2_V1,V2	VCRX2_V1,V2	RX2_BANDSEL[2:0]	RX2B_BANDSEL[1:0]	RX2C_BANDSEL[1:0]
TRX-A	< 450	01	10	101	XX	01
TRX-A	450 – 700	01	10	011	XX	11
TRX-A	700 – 1200	01	10	001	XX	10
TRX-A	1200 – 1800	01	10	000	01	XX
TRX-A	1800 – 2350	01	10	010	11	XX
TRX-A	2350 – 2600	01	10	100	10	XX
TRX-A	2600 – 6000	01	01	XXX	XX	XX
RX2-A	70 – 450	TT	01	101	XX	01
RX2-A	450 – 700	TT	01	011	XX	11
RX2-A	700 – 1200	TT	01	001	XX	10
RX2-A	1200 – 1800	TT	01	000	01	XX
RX2-A	1800 – 2350	TT	01	010	11	XX
RX2-A	2350 – 2600	TT	01	100	10	XX
RX2-A	>= 2600	TT	10	XXX	XX	XX

#### Transmit

TX Port	TX Filter (MHz)	VCTXR2_V1,V2	TX_ENABLE2A,2B	TX_BANDSEL[2:0]
TRX-A	< 117.7	10	01	111
TRX-A	117.7 – 178.2	10	01	110
TRX-A	178.2 – 284.3	10	01	101

TRX-A	284.3 – 453.7	10	01	100
TRX-A	453.7 – 723.8	10	01	011
TRX-A	723.8 – 1154.9	10	01	010
TRX-A	1154.9 – 1842.6	10	01	001
TRX-A	1842.6 – 2940.0	10	01	000
TRX-A	>= 2940.0	11	10	XXX

Note: Although the transmit filters are low pass, this table describes UHD's tuning range for selecting each filter path. The table also includes the required transmit enable state.

Note: X = don't care, T = If full duplex, set bits according to transmit table, otherwise don't care. Filter range A ? B will be selected if A <= freq < B.

#### Receive

RX Port	RX Filter (MHz)	VCTXR1_V1,V2	VCRX1_V1,V2	RX1_BANDSEL[2:0]	RX1B_BANDSEL[1:0]	RX1C_BANDSEL[1:0]
TRX-B	< 450	10	01	100	XX	10
TRX-B	450 – 700	10	01	010	XX	11
TRX-B	700 – 1200	10	01	000	XX	01
TRX-B	1200 – 1800	10	01	001	10	XX
TRX-B	1800 – 2350	10	01	011	11	XX
TRX-B	2350 – 2600	10	01	101	01	XX
TRX-B	2600 – 6000	10	10	XXX	XX	XX
RX2-B	70 – 450	TT	10	100	XX	10
RX2-B	450 – 700	TT	10	010	XX	11
RX2-B	700 – 1200	TT	10	000	XX	01
RX2-B	1200 – 1800	TT	10	001	10	XX
RX2-B	1800 – 2350	TT	10	011	11	XX
RX2-B	2350 – 2600	TT	10	101	01	XX
RX2-B	>= 2600	TT	01	XXX	XX	XX

#### Transmit

TX Port	TX Filter (MHz)	VCTXR1_V1,V2	TX_ENABLE1A,1B	TX1_BANDSEL[2:0]
TRX-B	< 117.7	00	01	111
TRX-B	117.7 – 178.2	00	01	110
TRX-B	178.2 – 284.3	00	01	101
TRX-B	284.3 – 453.7	00	01	100
TRX-B	453.7 – 723.8	00	01	011
TRX-B	723.8 – 1154.9	00	01	010
TRX-B	1154.9 – 1842.6	00	01	001
TRX-B	1842.6 – 2940.0	00	01	000
TRX-B	>= 2940.0	11	10	XXX

Note: Although the transmit filters are low pass, the following table describes UHD's tuning range for selecting each filter path. The table also includes the required transmit enable states.

- SSB/LO Suppression -35/50 dBc
- Phase Noise 3.5 GHz 1.0 deg RMS
- Phase Noise 6 GHz 1.5 deg RMS
- Power Output >10dBm
- IIP3 (@ typ NF) -20dBm
- Typical Noise Figure <8dB
  
- All RF Ports are matched to 50 Ohm with -10dB or better return loss generally. Detailed test is pending.
  
- Ettus Research recommends to always use the latest stable version of UHD
  
- Current Hardware Revision: 1
- Minimum version of UHD required: 3.8.0
- Required version on the host computer must match what is running on the E310
  
- Current Hardware Revision: 1
- Minimum version of UHD required: 3.8.5
- Required version on the host computer must match what is running on the E312
  
- 133 x 68 x 26.4 mm

- E310 0-40 °C
- E312 0-40 °C

- 10% to 90% non-condensing

E310 Schematics

E310 DB

E310 Architecture

Part Number	Description	Schematic ID (Page)
<b>Motherboard</b>		
TXS02612RTWR	SDIO PORT EXPANDER	U23 (2)
XC7Z020-1CLG484CES9919	FPGA	U11 (2,3,4,8,11,13)
<a href="#">Xilinx Zynq Product Page</a>	FPGA	-
USB3340-EZK-TR	ULPI Transceiver	U33 (5)
AK4571VQP	Audio CODEC	U30 (6)
FT230XQ-R	UART Interface	U32 (6)
88E1512	Gigabit Ethernet Transceiver	U13 (7)
24LC024/SN	EEPROM	U5 (9)
DS1339,SM	Real-Time Clock	U6 (9)
ADT7408	Temperature Sensor	U8 (9)
MPU-9150	Motion Processing Unit	U3 (9)
<a href="#">InvenSense MPU-9150 Product Page</a>	Motion Processing Unit	U3 (9)
BMP180	Digital pressure sensor	U4 (9)
BQ24192	Adapter Charger	U1 (10)
TPS54478	Step-Down Switcher	U20 (10)
MAX6510HAUT-T	Temperature Switches	U35 (10)
ATTINY88-MU	Microcontroller	U18 (10)
TPS61253YFF	Step-Up Converter	U19 (10)
AMY-6M	GPS Module	U12 (6)
<b>Daughterboard</b>		
Part Number	Description	Schematic ID (Page)
<a href="#">AD9361 Product Page</a>	2 x 2 RF Agile Transceiver	U8 (3)
24AA256	EEPROM	U15 (2)
TC-1-43A+	RF Transformer	T6 (3); T5 (3); T4 (3)
TC1-1-13M+	RF Transformer	T7 (3); T10 (3); T1 (3)
TPS62140	Step-Down Converter	U19 (4)
ADP1753ACPZ-R7	Linear Regulator	U17 (4); U18 (4)
SGA-4563Z	MMIC AMPLIFIER	U12 (5); U4 (5)
SKY13418-485LF	Antenna Switch	U13 (5); U3 (5); U16 (5); U2 (5); U10 (6); U5 (6)
SKY13373-460LF	SP3T Switch	U11 (6); U9 (6); U6 (6); U7 (6); SW4 (7); SW1 (7)
MGA-81563	Amplifier	U14 (5); U1 (5)
LFCN-5850+	Low Pass Filter	FL32 (5); FL1 (5)
LFCN-2750+	Low Pass Filter	FL37 (5); FL4 (5)
LFCN-2250+	Low Pass Filter	FL23 (6); FL20 (6)
LFCN-1700+	Low Pass Filter	FL40 (5); FL2 (5)
LFCN-1575+	Low Pass Filter	FL25 (6); FL17 (6)
LFCN-1000+	Low Pass Filter	FL33 (5); FL9 (5); FL27 (6); FL15 (6)
LFCN-575+	Low Pass Filter	FL36 (5); FL5 (5)
LFCN-530+	Low Pass Filter	FL29 (6); FL13 (6)
LFCN-400+	Low Pass Filter	FL38 (5); FL3 (5); FL30 (6); FL11 (6)
LFCN-225	Low Pass Filter	FL39 (5); FL6 (5)
LFCN-160+	Low Pass Filter	FL34 (5); FL8 (5)
LFCN-80+	Low Pass Filter	FL35 (5); FL7 (5)
HFCN-1600+	High Pass Filter	FL22 (6); FL19 (6)
HFCN-1100+	High Pass Filter	FL24 (6); FL16 (6)
HFCN-650+	High Pass Filter	FL26 (6); FL14 (6)
HFCN-440+	High Pass Filter	FL28 (6); FL12 (6)
BFCN-2435+	Bandpass Filter	FL21 (6); FL18 (6)
FDG6301N	Dual N-Channel, Digital FET	Q8 (7); Q5 (7)
HSMS-8202	Mixer Diodes	CR1 (7); CR2 (7); CR3 (7); CR4 (7)
LP5900TL	Linear Regulator	U25 (8)
ADP150AUJZ-3.0	Linear Regulator	U22 (8)
AD5662RBJ	16-Bit nanoDAC	U21 (8)

- Partial Enclosure 225 g
- Full Enclosure 375 g

- [File:E310 Dimensional Sketches.pdf](#)
- [File:cu e310 motherboard cca.pdf](#)
- [File:cu E310 daughtercard cca.pdf](#)
- [File:cu usrp-e310.pdf](#)

- [File:cu e312 motherboard cca.pdf](#)
- [File:cu e312 daughtercard cca.pdf](#)
- [File:cu ettus-e312.pdf](#)

- Utilization statistics are subject to change between UHD releases. This information is current as of UHD 3.9.4 and was taken directly from Xilinx Vivado 2014.4.

1. Slice Logic

Site Type	Used	Available	Util%
Slice LUTs	36203	53200	68.05
LUT as Logic	28108	53200	52.83
LUT as Memory	8095	17400	46.52
LUT as Distributed RAM	870		
LUT as Shift Register	7225		
Slice Registers	36562	106400	34.36
Register as Flip Flop	36562	106400	34.36
Register as Latch	0	106400	0.00
F7 Muxes	376	26600	1.41
F8 Muxes	125	13300	0.93

3. Memory

Site Type	Used	Available	Util%
Block RAM Tile	97	140	69.28
RAMB36/FIFO*	90	140	64.28
RAMB36E1 only	90		
RAMB18	14	280	5.00
RAMB18E1 only	14		

\* Note: Each Block RAM Tile only has one FIFO logic available and therefore can accommodate only one FIFO36E1 or one FIFO18E1. However, if a

4. DSP

Site Type	Used	Available	Util%
DSPs	120	220	54.54
DSP48E1 only	120		

- 10/100/1000 BASE-T Ethernet
- Stereo audio out, mono mic in
- Integrated GPS receiver
- Host USB support
- 9-axis IMU

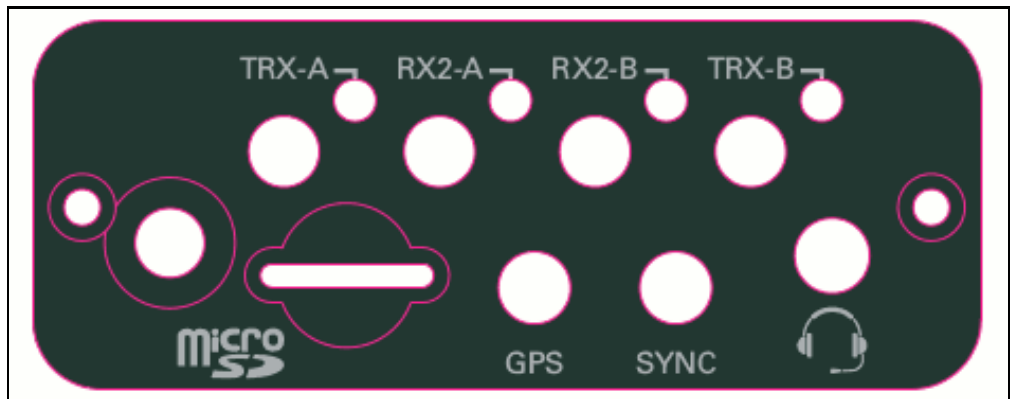
• RF A Group

- ◆ **TX/RX LED:** Indicates that data is streaming on the TX/RX channel on frontend side A
- ◆ **RX2 LED:** Indicates that data is streaming on the RX2 channel on frontend side A

• RF B Group

- ◆ **TX/RX LED:** Indicates that data is streaming on the TX/RX channel on frontend B
- ◆ **RX2 LED:** Indicates that data is streaming on the RX2 channel on frontend B

- **PWR:** Power switch with integrated status LED, for status



description see below.

- **SYNC:** Input port for external PPS signal
- **GPS:** Connection for the GPS antenna
- **AUDIO:** Audio input / output

The status LED in the power switch indicates the power and charge status. It's behavior is firmware version dependent.

- **Version 1** (original E310)
  - ◆ **Off:** Indicates device is off and not charging
  - ◆ **Solid Red:** Indicates device is charging
  - ◆ **Solid Green:** Indicates device is on
  - ◆ **Fast Blinking Red:** Indicates an error code
    - ◇ 1 - Low voltage error
    - ◇ 2 - Regulator low voltage error
    - ◇ 3 - FPGA power error
    - ◇ 4 - DRAM power error
    - ◇ 5 - 1.8V rail power error
    - ◇ 6 - 3.3V rail power error
    - ◇ 7 - Daughterboard / TX power error
    - ◇ 9 - Temperature error
- **Version 2** (E312 and upgraded E310)
  - ◆ **Off:** Indicates device is off and not charging
  - ◆ **Slow Blinking Green:** Indicates device is off and charging
  - ◆ **Fast Blinking Green:** Indicates device is on and charging
  - ◆ **Solid Green:** Indicates device is on (and not charging, if E312)
  - ◆ **Solid Orange:** Indicates device is on and discharging
  - ◆ **Fast Blinking Orange:** Indicates device is on, discharging, and charge is below 10% charge
  - ◆ **Fast Blinking Red:** Indicates an error code
    - ◇ 1 - Low voltage error
    - ◇ 2 - Regulator low voltage error
    - ◇ 3 - FPGA power error
    - ◇ 4 - DRAM power error
    - ◇ 5 - 1.8V rail power error
    - ◇ 6 - 3.3V rail power error
    - ◇ 7 - Daughterboard / TX power error
    - ◇ 8 - Charger error
    - ◇ 9 - Charger temperature error
    - ◇ 10 - Battery low error
    - ◇ 11 - Fuel Gauge temperature

error  
 ◇ 12 - Global  
 (case)  
 temperature  
 error

- **PWR:** Locking connector (Kycon KLDHCX-0202-A-LT) for the USRP-E Series power supply
- **1G ETH:** RJ45 port for Ethernet interfaces
- **USB:** USB 2.0 Port
- **SERIAL:** Micro USB connection for serial uart console



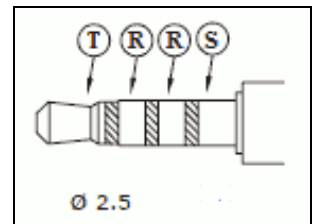
### Pin Mapping

- Pin 1: +3.3V
- Pin 2: Reserved
- Pin 3: Data[5]
- Pin 4: Reserved
- Pin 5: Data[4]
- Pin 6: Data[0]
- Pin 7: Data[3]
- Pin 8: Data[1]
- Pin 9: 0V
- Pin 10: Data[2]



- Please see the [E3x0/X3x0 GPIO API](#) for information on configuring and using the GPIO bus.

- The E3x0 2.5 mm Audio Jack TRRS pins are assigned as follows: Tip=Mic, Ring1=Right, Ring2=Left, Sleeve=GND.
- The Left/Right audio outputs are compatible with typical low-impedance headphones (16 to 32 Ohms). The Microphone pin provides approximately 2 mA bias at 2.2 V when not suspended. A variety of pin configurations can be found on commonly available headsets, so an adapter may be required.



The USRP E312 is equipped with an integrated 3.7V, 3200mAh lithium-ion battery cell. After unboxing the USRP E312, plug in the power adapter to an AC power source and fully charge the battery. This process will take approximately 2 hours. Do not leave the USRP E312 unit plugged in for more than 24 hours.

The status LED in the power button indicates the power and charge status of the battery:

Off: Indicates device is off and not charging.

- Slow Blinking Green: Indicates device is off and charging.
- Fast Blinking Green: Indicates device is on and charging.
- Solid Green: Indicates device is on and not charging (Battery is finished charging).
- Solid Orange: Indicates device is on and discharging.
- Fast Blinking Orange: Indicates device is on, discharging, and charge is below 10% charge.
- Fast Blinking Red: Indicates an error code:

1. Low Voltage Error
2. Regulator Low Voltage Error
3. FPGA Power Error
4. DRAM Power Error
5. 1.8V Power Rail Error
6. 3.3V Power Rail Error
7. Daughterboard / TX Power Error
8. Charger Error
9. Charger Temperature Error
10. Battery Low Error
11. Fuel Gauge Temperature Error
12. Global (Enclosure) Temperature Error

The battery life of the USRP E312 in idle mode is approximately 5 1/2 hours. The battery will enable the USRP E312 to operate for approximately 2 hours 20 minutes, when transmitting and receiving on both channels (2x2 MIMO), with maximum gain settings, at 5 GHz center frequency, and 1 MS/s sample rate. When the power button status LED is in the "Fast Blinking Orange" mode, plug the USRP E312 into an AC power source as soon as possible to recharge the battery.

If the power button status LED indicates a "Low Voltage Error" (codes 1, 2, 3, 4, 5, 6, 7) or a "Battery Low Error" (code 10), plug the USRP E312 into an AC power source as soon as possible to recharge the battery.

When the power button status LED indicates a "Temperature Error" or "Charger Error" (codes 8, 9, 11, or 12), power off the USRP E312 unit and allow it to cool down to room temperature. Then, plug in the USRP E312 to an AC power source and fully charge the battery.

If error codes persist after cooling down and/or recharging the USRP E312, please contact [support@ettus.com](mailto:support@ettus.com).

You can purchase a replacement battery for the E312 at <https://www.ettus.com/product/details/E312-battery>.

An Application Note covering the replacement of the E312 battery can be found at [USRP E312 Battery Replacement Instructions](#).

As of December 1st, 2010 all Ettus Research products are RoHS compliant unless otherwise noted. More information can be found at <http://ettus.com/legal/rohs-information>

- [Media:volatility USRP E310 r1.pdf](#)
- [Media:USRP E31x CoV.pdf](#)

The E31x SD card images can be obtained two ways:

- Using `uhd_images_downloader`. See these instructions: [https://files.ettus.com/manual/page\\_usrp\\_e3xx.html#update\\_sdcard](https://files.ettus.com/manual/page_usrp_e3xx.html#update_sdcard)
- Direct download from <https://files.ettus.com/binaries/cache/e3xx/>

**Note:** Obsolete images, such as the alpha, beta, and Release 4 images, are located here: [https://files.ettus.com/e3xx\\_images/](https://files.ettus.com/e3xx_images/). These release are no longer supported and provided here for archival purposes only.

If choosing to directly download the SD card image, please note that they are sorted by UHD version with the format `meta-ettus-vUHD_VERSION`. For example, the UHD 4.5 release is `meta-ettus-v4.5.0.0`. Each release contains SD card images and the SDK (OE cross-compiler build environment) for the USRP E31x. There is a manifest file that shows which packages, and which versions, are included in the OE build within each folder.

We highly recommend customers use UHD 4.5 or later. It is fine if you are already successfully using an older version, but at some point it is recommended that you upgrade to a current version so that you benefit from the latest bug fixes, new features, stability improvements, and other enhancements.

The UHD 4.5+ release images include UHD 4.5 (or later), GNU Radio 3.8, Python 3, and the corresponding FPGA image file.

**Note:** An 8 GB SD card is required for the Release 4 image.

The SD card image contains both the FPGA image and the OS for the E31x. The FPGA image is located in the file system of the E31x in the `/usr/local/share/uhd/images` directory.

The E31x image comes in two speed grade varieties, `sg1` and `sg3`. The majority of USRP E31x devices use the `sg3` image, but older devices may use `sg1`. The version that you will need depends on the product number of your E31x, which is printed on the bottom of the device.

E310 (15633X-01L)	X= A, B, C, D	e3xx_e310_sg1
	X= E or later	e3xx_e310_sg3
E312 (140605X-01L)	X = All	e3xx_e310_sg3

For the E310, the product number will be `156333X-01L`, where X is a letter from A to Z. For devices where X is A, B, C, D, the image starting with `e3xx_e310_sg1` should be used. For devices where X is E or later, the images under the `e3xx_e310_sg1` folder should be used. You must use the appropriate image for your specific device. The incorrect image will not work, and will only boot as far as the U-Boot boot loader before stopping.

For the E312, the product number will be `140605X-01L`, where X is a letter from A to Z. The image starting with `e3xx_e310_sg3` folder should be used for all E312 devices.

You can burn the image to an SD card using the "dd" tool. Instructions on how to use this tool are located at the links below:

- [https://files.ettus.com/manual/page\\_usrp\\_e3xx.html#e3xx\\_sdcard](https://files.ettus.com/manual/page_usrp_e3xx.html#e3xx_sdcard)
- [https://kb.ettus.com/Writing\\_the\\_USRP\\_File\\_System\\_Disk\\_Image\\_to\\_a\\_SD\\_Card](https://kb.ettus.com/Writing_the_USRP_File_System_Disk_Image_to_a_SD_Card)

The SD image files have an \*.zip extension. You can uncompress these files with any zip compatible tool, such as 7-Zip. Please see the links below for further information.

## 7-Zip

- <http://www.7-zip.org/>
- <https://en.wikipedia.org/wiki/7-Zip>

The OpenEmbedded project reported a security vulnerability for OE-Core (<http://lists.openembedded.org/pipermail/openembedded-architecture/2017-June/000638.html>). If you are an USRP E-Series user that is building binary ipkgs which you then distribute to your customers, you may be affected by this issue. No other workflows are impacted.

The vulnerability is documented as CVE-2017-9731 (<https://cve.mitre.org/cgi-bin/cvename.cgi?name=2017-9731>). The specific issue is that information in the `src_URI` for software repositories used by OE recipes is "leaked" by binary ipkgs. For example, if you are using the E-Series OE-generated SDK to build binary ipkgs, and the `URI` you use for your source code repository contains sensitive information (e.g., `https://github.com/company-name/secret-project-name`, or `local-server.internal.com?USER=admin&PASSWORD=password`), then that information will be leaked in the `Source:` field of the ipkg.



The OpenEmbedded team has merged a fix for this into OE-Core `master`, and backported the change to previous versions of OpenEmbedded. Generally, including sensitive information in the `SRC_URI`s is not a good idea, and we highly recommend users avoid doing this in their build process. Some recommendations provided on the OpenEmbedded discussion list:

- Use non-confidential path names (i.e., don't include confidential customer or project names in build paths).
- Change or manage the host name of your build system so that it is non-confidential, like `build-1` instead of `secret-product.my-company.internal.com`.
- Use a "build user" who does not have network credentials to access sensitive machines during the build process.

If you have any questions about this, or need help determining if this issue affects you, please let us know by contacting [support@ettus.com](mailto:support@ettus.com).

- [COMPASS HEADING USING MAGNETOMETERS](#)

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