Configuration of the UT200SpW4RTR

Table 1: Cross Reference of Applicable Products

Product Name:	Manufacturer Part Number	SMD #	Device Type	Internal PIC
200 Mbps 4-port SpaceWire router	UT200SpW4RTR	5962-08244	01	WD41

Introduction

The purpose of this application note is to review how to configure the UT200SpW4RTR SpaceWire router. General information from the SpaceWire Standard, ECSS-E-ST-50-12C, as it relates to configuration of the UT200SpW4RTR is also reviewed.

SpaceWire and Networking

A SpaceWire network is made up of a number of SpaceWire nodes interconnected by SpaceWire routing switches. SpaceWire nodes can be routers, sensors, memory units, processors, and telemetry sub-systems. Nodes are the sources and destinations of SpW packets and provide the interface to the application systems. SpaceWire nodes can connect directly together using point-to-point SpaceWire links or interconnected using SpaceWire routers. The UT200SpW4RTR- 4 Port SpaceWire router has four SpW ports and allows any port to pass data internally or externally to any of the other ports.

If a SpaceWire network is going to be connected using routers, the routers need to be configured to achieve desired packet routing scheme. Routers use path addressing when initiating a configuration transaction. A configuration transaction initiates by sending a path addressed packet with the first byte of the packet containing Hex value 0x00. This allows access to the configuration registers and look up tables.

Addressing

Path Addressing is defined as a series of one or more characters at the start of the packet that define the route, or path, that the packet should take across a SpaceWire network. The destination address is specified as a sequence of router output port numbers used to route the packet across the network. Path Addressing is used for configuration of the router.

The router can be configured to use Logical Addressing using path addressing to configure the look up tables. Logical Addressing contains a character at the start of a packet, which identifies a look up table location, and selects the destination for the packet. Each destination address has a unique number or logical address associated with it. To access logical routing the user must configure the look-up tables. The look up tables have even parity.

The last SpaceWire addressing scheme is Group Adaptive. When Group adaptive routing is used packets can be routed to a requested destination through different network paths. Group Adaptive routing can be set up for 2 paths in the UT200SpW4RTR. To utilize Group Adaptive

routing the user must configure Group Adaptive bits in the look-up table space. Bits 5 through 9 are group adaptive address, and Bit 11 must be set to 0x01 to enable group adaptive routing.

To use Logical or Group Adaptive addressing, the router must be configured to set up these functions. More information as well as examples are provided in this application note. The configuration protocol discussed below follows the SpaceWire standard (ECSS-EST-50-12C) requirement of the leading data character with a value 0x00 resulting in the packet being routed to the configuration logic. Aeroflex employs a specific configuration scheme that is described below for the UT200SpW4RTR.

Configuration Protocol
The following section describes the Configuration Protocol specific to the UT200SpW4RTR. The SpW standard does not currently specify a configuration protocol. The UT200SpW4RTR is configured through any one of the four SpaceWire ports or the External Port. The default configuration is for all ports to be configuration ports. If one or more ports are configured to be the configuration port, be sure that only one configuration command is sent at a time. Not doing this could result in corruption of the packet.

The first byte of data with value 0x00 received by any router port after reset or an EOP/EEP initiates a configuration transaction. (ECSS-E-ST-50-12C). Configuration transactions allow access to the lookup tables, configuration registers and status registers.

A Configuration Write transaction writes a 16-bit data word to the specified 16-bit address location in the Configuration memory space. The packet begins with zero or can contain additional router address bytes, followed the final destination address byte set to zero. This addresses the configuration memory space.

The second byte is the Router ID, which is a hardwired 8-bit value used to uniquely identify the router from all others on the switched fabric. This value must match the targeted router or the command will be ignored.

The third byte is the Protocol ID. This allows different protocols to be used on a SpW network. The SpaceWire Working Group is still working on defining this portion of the configuration protocol. Protocol IDs in the range of 1 to 239 are guaranteed not to clash, 255 is reserved, 245 if no logical address. ID 0x01 is defined for Remote memory Access Protocol (RMAP) and 0x02 is reserved for Reliable Data Delivery (RDD). If no specific protocol is going to be used 0x00 can be entered in the Protocol ID byte.

The fourth byte is the Packet Type, which has 4 defined types: 1. "write", 2. "read-no-clear", 3. "read-clear", and 4. "read-response". For a configuration packet type "write" needs to be selected. The next two bytes are the Address Least Significant Byte (LSB), followed by the Address Most Significant Byte (MSB). These address locations correspond to the location where the data is going to be written in the configuration space, like the look up tables, port configuration, etc.

The Data LSB and Data MSB directly follow the address bytes. This is the data the user wants to write into look-up table or register configuration. The last byte before the end of packet (EOP) will be the arithmetic checksum value, which is an arithmetic sum of the final destination address, the Router ID, the Packet Type, the Address and Data bytes. If the checksum value does not match, the command will not be executed. If the packet has less than eight (8) bytes or the Checksum value is not the last byte, the command will not be executed (refer to ECSS-E-ST-50-12C). See Figure 1. The Hex 0x00 in the second field of the configuration write packet is the configuration packet designation.

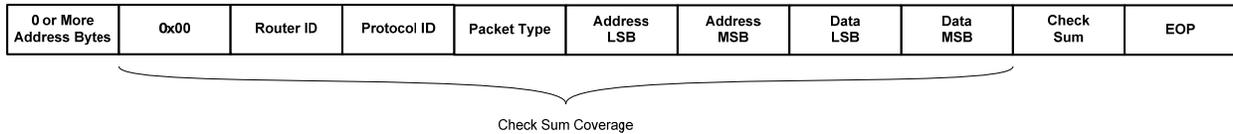| 0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Data LSB	Data MSB	Check Sum	EOP

Check Sum Coverage

Figure 1.
Configuration Port Write Packet Command

A Configuration Read packet reads a number (Count) of 16-bit data values from consecutive 16-bit address locations and transmit the data to the return location specified. This packet also begins with zero or can contain additional address bytes, followed by the final destination address byte set to zero. Checksum is calculated as shown in Figure 2.

The Router ID byte should be set to the value in the Router Identification register, unless the Router ID is being read. Protocol ID follows the Router ID byte, then the Packet Type byte should be set to "read", either "read-no-clear", or "read-clear" can be used. Followed by the address least significant byte, the address most significant byte, the word count byte, and one or more return path address byte(s). The order of the return path address bytes is to read them in the order they are received.

That is to say, the first return path address byte will be the path out of the first router with subsequent bytes to be used for the next layers of routers. The last byte will be the Checksum value, which is an arithmetic sum of the Destination Address, Router ID, Protocol ID, Packet Type, Address' LSB/MSB, Data LSB/MSB and return path bytes. If the checksum received does not match the calculated value, an error end of packet is then sent to the return address. The word count byte must be greater than zero. A value of zero causes the command to not be executed. The return address path must contain one or more bytes and the first header byte must not be zero; otherwise the command will be considered invalid and not be executed.

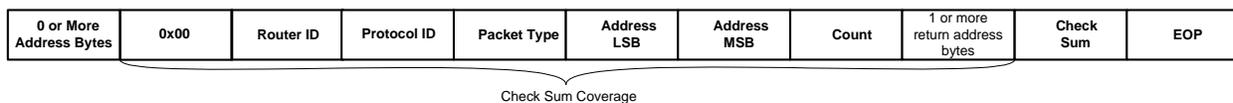| 0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Count	1 or more return address bytes	Check Sum	EOP

Check Sum Coverage

Figure 2.
Configuration Port Read Packet Command

The Read Response configuration packet is the response to the Read Command. This packet does not contain a Destination Address equal to zero, but one or more physical or logical addresses that corresponds to the Return Address field in the Read Command Packet. These initial bytes are followed by the Router ID, Protocol ID, Packet Type (set to read response), the starting point of the addresses you want to respond to the read with Address LSB, the starting Address MSB. Then one or more Data LSB/MSB (16-bits) that corresponds to the Count field value in the Read Command Packet. The last byte is the Checksum byte, and then the EOP.
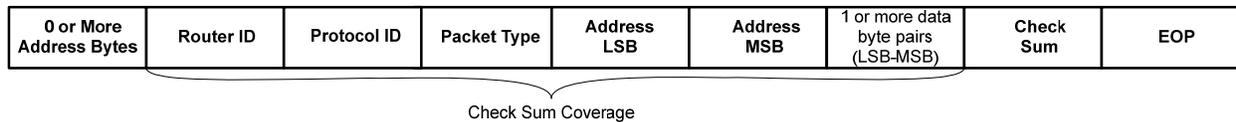
0 or More Address Bytes	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	1 or more data byte pairs (LSB-MSB)	Check Sum	EOP

Check Sum Coverage

Figure 3.
Configuration Port Read Packet Response

Logical Addressing Configuration Example

The following is an example of how to configure each of the routers acting as nodes on the 6 node network in figure 5, below. This is a simplified network topology and only utilized 2 or 3 of the available 5 ports on the 4 Port SpaceWire Router. The SpaceWire standard states that Path Addressing must be used for configuration (ECSS-E-ST-50-12C).

The fourth byte in both the Configuration Write and Read, or the third byte in the Read Response, is the Packet Type field. The Figure below provides the hex values for the available packet types.

Packet Type	Value (Hex)
Write	0x00
Read No Clear	0x01
Read Clear	0x02
Read Response	0x03
Reserved	0x04-0xFF

Figure 4.
Packet Type Table

The network configuration will start at the Primary router (Router P) and continue clock wise around the network ring (A – B – C – D – E)

Figure 5.
Example network topology

The look up table data format is:

Figure 6.
Look up table locations format

With the format of each of the 16 bits within the look up table as follows:

Parity	Unused			Enable Group Adaptive	Enable Header Delete	Group Adaptive Address Bits					Primary Logical Address Bits				
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Figure 7.
Look up table bit format

The five LSB bits [4:0] are the Primary Logical Address bits and are for selecting ports 1 through 4 regardless of whether Group Adaptive has been enabled or not. When Group Adaptive has been enabled the router looks at the port address specified by these bits first, and if the designated port is busy, then looks at the port specified by the Group Adaptive Address Bits.

Bits [9:5] are used when Group Adaptive has been enabled and the port selected by the Primary Logical Address Bits is busy.

Bit [10] is used to enable the header delete function for the port selected by either the Group Adaptive Address Bits or the Primary Logical Address Bits. Whenever this bit is set high, the router deletes the header before sending the packet out of the requested transmit port.

Bit [11] is used to enable the Group Adaptive function on the router. Setting this bit high tells the router to use bits [9:5] for the port select in the event the port select for the Primary Address Bits is busy. Unused Bits [14:12] need to be set to 0x00 for the parity calculation.

A Parity Bit is included for each lookup table location. When the header byte is decoded and falls between address 0x20 and 0xFF, a lookup table address will be retrieved by the lookup table (Logical Address). The parity is calculated based on the bits in the lookup table not including the parity bit. The parity is then compared to the calculated parity and if they are not the same the packet will be read out of the receive FIFO up to and including the EOP. This is commonly referred to as "spilling the packet." Additionally, the Parity Error Register will be incremented.

Parity	Unused			Enable Group Adaptive	Enable Header Delete	Group Adaptive Address Bits					Primary Logical Address Bits				
15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

Data MSB   Data LSB

Figure 8.
Look up table Data format

Figure 8 shows how the look up table bit format shown in figure 7 is related to the Configuration Port Write and Read Packet Commands. The data used to configure the primary logical address

bits and bits [5:7] of the group adaptive bits will be contained in the Data LSB as it appears in the Configuration Port Write and Read Commands.

Before configuration of the SpW network takes place some initial set up of each routers' configuration and status registers should take place to ensure proper operation. Figure 9 shows the configuration and status registers that are available on the UT200SpW4RTR.

The Configure Port Enable Register resides at location 0x0102 and should be set to the system port (port5) on the primary router or Router P. Configuring only one configuration port on a router will prevent configuration packets being corrupted when multiple ports are set up as configuration ports. If more than one port is set up as a configuration port and more than one configuration command is sent within the router the configuration packets will be corrupted. The following example shows how to configure Router P such that the System or External port is enabled and SpaceWire ports 1 to 4 are disabled for Configuration of the router.

<u>EXAMPLE</u>: Configure Port Enable for Router P.

Write configuration protocol into port 5 (System Port) of the Primary router

- Use Write configuration protocol into port 5 (System Port) of the router
- Address Bytes: NONE Needed
- 0x00 for configuration
- Router ID: 00 For Router P (default)
- Protocol ID: 00 for no protocol used
- Packet Type: 00 is Write
- Set up Data Format
    o Address LSB: 02 LSB
    o Address MSB: 01 MSB of register location 0x0102
- Write in Data
    o Data LSB: 10   Bit15   8 7   4   0
    o Data MSB: 00   00000000 00010000
- Checksum: 14
- EOP: 100000000

	00	01	00	00	02	01	00	10	14	100000000
0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Data LSB	Data MSB	Check Sum	EOP

Next, the Router Identification register that resides at location 0x0100 should be configured for each router in this example network, the Router ID will be used in the Write and Read configuration packet commands.

<u>EXAMPLE</u> Configure Router ID for Router A.

Write configuration protocol into port 5 (System Port) of the Primary router to set up look up tables.

- 0x01 Address Bytes to go out of port 1 of Router P
- 0x00 for configuration
- Router ID: 00 is the default router ID for Router A, since Router ID it is not set up yet
- Protocol ID: 00 for no protocol used
- Packet Type: 00 is Write
- Set up look-up table
  - Address LSB: 00 LSB of register location 0x0100, Router ID
  - Address MSB: 01 MSB of Router ID register
- Write in Data
  - Data LSB: 0A
  - Data MSB: 00
- Checksum: 0B this is the sum of the final destination address, router ID, packet type, and the address and data bytes. 0x00+0x00+0x00+0x00+0x00+0x01+0x0A+0x00= 0x0B
- EOP: 100000000

01	00	00	00	00	00	01	0A	00	0B	100000000
0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Data LSB	Data MSB	Check Sum	EOP

The sequence to configure Router A's router ID can be followed for the other routers in the network. This general concept can also be used to configure any of the registers that are write capable.

<u>EXAMPLE</u> Configure Router P. to set up a look up table location

Write configuration protocol into port 5 (System Port) of the Primary router to set up look up tables.
- Write directly into port 5 of Router P, no Address Bytes required
- 0x00 for configuration
- Router ID: 00 is router ID for Router P (default)
- Protocol ID: 00 for no protocol used
- Packet Type: 00 is Write
- Set up look-up table
  - Address LSB: 20 sets up first address in look up table
  - Address MSB: 00 The address MSB is always 00 because the address range of the Logical Addresses is 0x0020 to 0x00FF
- Write in Data
  - Data LSB: 01 sets up port 1 of Router P (this will set up logic such that is register 20 is received the data will go out of port 1 on Router P)
  - Data MSB: 04 Header Delete set.
- Checksum: 26 this is the sum of the final destination address, router ID, packet type, and the address and data bytes. 0x00+0x01+0x00+0x20+0x00+0x01+0x04 = 0x26
- EOP: 100000000

	00	01	00	00	20	00	01	04	26	100000000
0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Data LSB	Data MSB	Check Sum	EOP

The data characters would look like:

EOP	1	0	0	0	0	0	0	0	0	
Check Sum	0	0	0	1	0	0	1	1	0	0x26
Data MSB	0	0	0	0	0	0	1	0	0	0x04
Data LSB	0	0	0	0	0	0	0	0	1	0x01
Address MSB	0	0	0	0	0	0	0	0	0	0x00
Address LSB	0	0	0	1	0	0	0	0	0	0x20
Packet Type	0	0	0	0	0	0	0	0	0	0x00
Protocol ID	0	0	0	0	0	0	0	0	0	0x00
Router ID	0	0	0	0	0	0	0	0	1	0x00
0x00	0	0	0	0	0	0	0	0	0	0x00
	8								0	

<u>EXAMPLE</u> Configure Router A lookup table location

- Address bytes 01, go out port 1 of Router P
- 0x00 for configuration
- Router ID: 0A is router ID for Router A
- Protocol ID: 00 for no protocol used
- Packet Type: 00 is Write 0x00
- Set up look-up table
  - Address LSB: AF sets up lookup table address 0xAF
  - Address MSB: 00 The address MSB is always 00 because the address range of the Logical Addresses is 0x0020 to 0x00FF
- Write in Data
  - Data LSB: 04 sets up port 4 of Router A (this will set up logic such that is register AF is received the data will go out of port 4 on Router A)
  - Data MSB: 04 Header Delete set.
- Checksum: C0 this is the sum of the final destination address, router ID, packet type, and the address and data bytes. 0x00+0x00+0x0A+0xAF+0x00+0x04+0x04 = 0xC1
- EOP: 100000000

01	00	0A	00	00	AF	00	04	04	C1	100000000
0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Data LSB	Data MSB	Check Sum	EOP

EXAMPLE Configure Router E look up table location

- Address bytes: 01 02 02 02 02, go out port 1 of Router P, then out of port 2 on Router A, then out of port 2 on Router B, then out of port 2 on Router C, then out of port 2 on Router D
- 0x00 for configuration
- Router ID: 0E is router ID for Router E
- Protocol ID: 00 for no protocol used
- Packet Type: is Write 0x00
- Set up look-up table
    - Address LSB: FE sets up lookup table address 0xFE
    - Address MSB: 00 The address MSB is always 00 because the address range of the Logical Addresses is 0x0020 to 0x00FF
- Write in Data
    - Data LSB: 03 sets up port 3 of Router E (this will set up logic such that is register FE is received the data will go out of port 3 on Router E)
    - Data MSB: 0C Header Delete set.
- Checksum: E1 this is the sum of the final destination address, router ID, packet type, and the address and data bytes. 0x00+0x00+0x0E+0xCC+0x00+0x03+0x0C = 0xE9
- EOP: 100000000

01 02 02 02 02	00	0E	00	00	CC	00	03	0C	E9	100000000
0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Data LSB	Data MSB	Check Sum	EOP

-OR-

- Address bytes: 02, go out port 2 of Router P
- 0x00 for configuration
- Router ID: 0E is router ID for Router E
- Protocol ID: 00 for no protocol used
- Packet Type: is Write 0x00
- Set up look-up table
    - Address LSB: FE sets up lookup table address 0xFE
    - Address MSB: 00 The address MSB is always 00 because the address range of the Logical Addresses is 0x0020 to 0x00FF
- Write in Data
    - Data LSB: 03 sets up port 3 of Router E (this will set up logic such that is register FE is received the data will go out of port 3 on Router E)
    - Data MSB: 0C Header Delete set.
- Checksum: 107 this is the sum of the final destination address, router ID, packet type, and the address and data bytes. 0x00+0x00+0x0E+0xCC+0x00+0x03+0x0C = 0xE9
- EOP: 100000000

02	00	0E	00	00	CC	00	03	0C	E1	100000000
0 or More Address Bytes	0x00	Router ID	protocol ID	Packet Type	Address LSB	Address MSB	Data LSB	Data MSB	Check Sum	EOP

EXAMPLE Read Router A packet command

- Address Bytes: 01, receive on port 1 Router P
- 0x00 for configuration
- Router ID: 0A is router ID for Router A
- Protocol ID: 00 for no protocol used
- Packet Type: is Read No Clear 0x01
- Address LSB: AF sets up to read from address 0xAF
- Address MSB: 00 sets up to read from address 0x00
- Count: 02 will read 2 Bytes of data. Count can only be an even number. To read one register you must enter 0x02, to read 2 registers you must enter 0x04, etc.
- Checksum: C2 this is the sum of the router ID, packet type, address bytes, count, an return address bytes. 0x00+0x0A+0x01+0xAF+0x00+0x02+0x01+0x05= 0xC2
- Return Address Bytes: 01 05 out port 1 of Router A, out port 5 Router P

01	00	0A	00	01	AF	00	02	01 05	C2	100000000
0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Count	1 or More Return Address Bytes	Check Sum	EOP

The Data Character would look like:

EOP	1	0	0	0	0	0	0	0	0	
Check Sum	0	1	1	0	0	0	0	1	0	0xC2
Return Address Bytes	0	0	0	0	0	0	1	0	1	0x05
Return Address Bytes	0	0	0	0	0	0	0	0	1	0x01
Count	0	0	0	0	0	0	0	1	0	0x02
Address MSB	0	0	0	0	0	0	0	0	0	0x00
Address LSB	0	1	0	1	0	1	1	1	1	0xAF
Packet Type	0	0	0	0	0	0	0	0	1	0x01
Protocol ID	0	0	0	0	0	0	0	0	0	0x0A
Router ID	0	0	0	0	0	1	0	1	0	0x00
0x00	0	0	0	0	0	0	0	0	0	0x00
Address Bytes	0	0	0	0	0	0	0	0	1	0x01
	8								0	

EXAMPLE Read Router B packet command
- Address Bytes: 01 02, Router A receives command on port 1 of Router P, then sent out port 2 on Router A, Router B receives command on port 1 from Router A
- 0x00 for configuration
- 0B is router ID for Router B
- Protocol ID: 00 for no protocol used
- Packet Type: is Read No Clear 0x01
- Address LSB: AB sets up to read from address 0xAB
- Address MSB: 00 sets up to read from address 0x00
- Count: 32 will read 16 Registers starting from register 0xAB
- Return Address Bytes: 01 01 05 out port 1 of Router B, out port 1 of Router A, out port 5 Router P
- Checksum: F0 this is the sum of the router ID, packet type, address bytes, count, an return address bytes. 0x00+0x0B+0x01+0xAB+0x00+0x32+0x01+0x01+0x05= 0xF0

01 02	00	0B	00	01	AB	00	32	01 01 05	f0	100000000
0 or More Address Bytes	0x00	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	Count	1 or More Return Address Bytes	Check Sum	EOP

Data Characters:

EOP	1	0	0	0	0	0	0	0	0	
Check Sum	0	1	1	1	1	0	0	0	0	0xF0
Return Address Bytes	0	0	0	0	0	0	1	0	1	0x05
Return Address Bytes	0	0	0	0	0	0	0	0	1	0x01
Return Address Bytes	0	0	0	0	0	0	0	0	1	0x01
Count	0	0	0	1	1	0	0	1	0	0x32
Address MSB	0	0	0	0	0	0	0	0	0	0x00
Address LSB	0	1	0	1	0	1	0	1	1	0xAB
Packet Type	0	0	0	0	0	0	0	0	1	0x01
Protocol ID	0	0	0	0	0	0	0	0	0	0x00
Router ID	0	0	0	0	0	1	0	1	1	0x0B
0x00	0	0	0	0	0	0	0	0	0	0x00
Address Bytes	0	0	0	0	0	0	0	1	0	0x02
Address Bytes	0	0	0	0	0	0	0	0	1	0x01
	8								0	

<u>EXAMPLE</u> Read Response from Router B

A read response will be returned to the user after a Read command is initiated.

- Address Bytes: 01 02, receive on port 2 of Router A, then receive on port 1 Router P
- Router ID: 0B is router ID for Router B
- Protocol ID: 00
- Packet Type: is Read Response 0x03
- Address LSB: 0xAB, will return the LSB addresses the user requested the read on
- Address MSB: 0x00, will return the MSB addresses the user requested the read on
- Data Byte Pairs: returned data contained in the addresses the user initiated the read on.
- Check Sum: This will include the Router ID, Packet Type, Address LSB and MSB, and the returned Data Byte Pairs.
- EOP: 100000000

01 02	0B	00	03	AB	00	Data from 0x00AB to 0x00BB		100000000
0 or More Address Bytes	Router ID	Protocol ID	Packet Type	Address LSB	Address MSB	1 or More Data Byte Pairs	Check Sum	EOP

Summary
Initial router set up and configuration can be completed in any order the designer would like. The examples provided in this application note are intended to be used as an example to help the user get stared using the UT200SpW4RTR.