DWAM79
D2D
Rev1.3

DWAM79_D2D Digital Wireless Audio Module

1 DWAM79_D2D Module

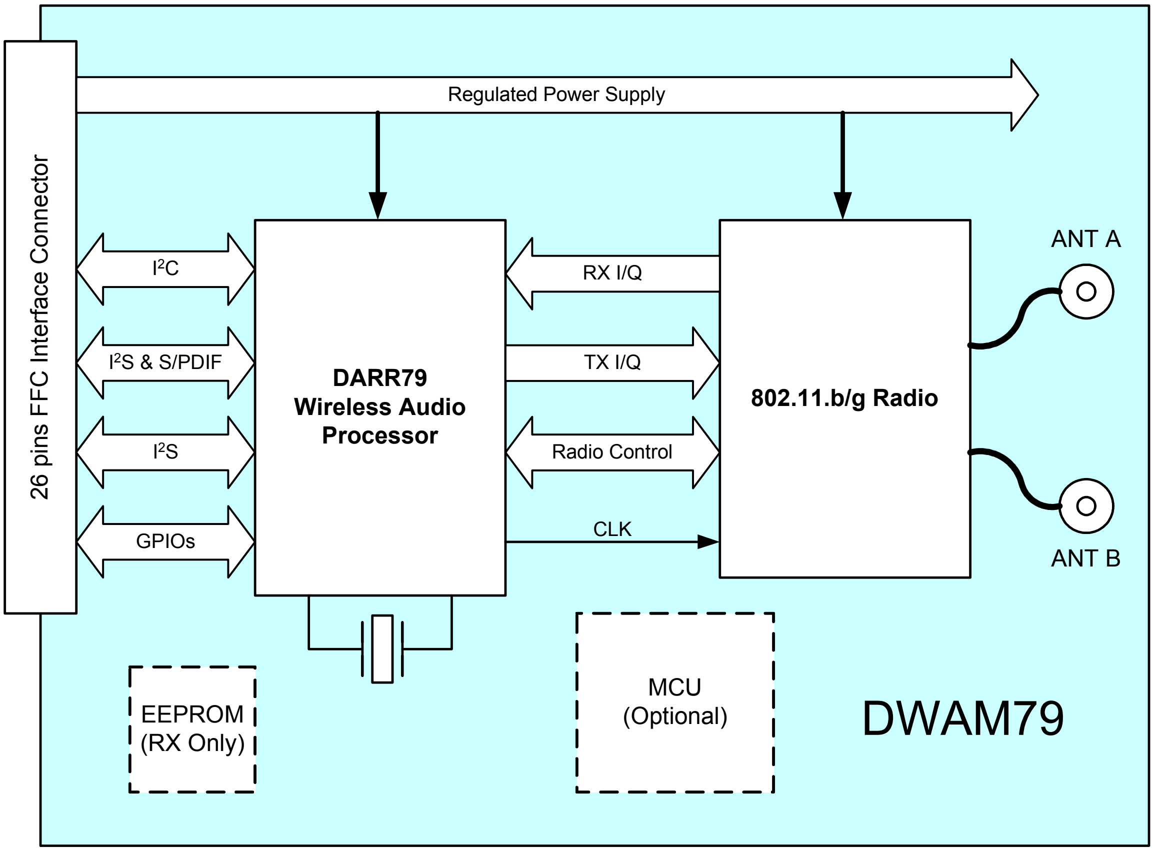
1.1 Product Description

The DWAM79_D2D is an OEM module (42x42mm) based on the STS DARR79. It is a wireless digital audio transceiver operating in the 2.4GHz ISM band. The wireless audio link supports up to 4 high quality and low latency audio channels in various network topologies. A unique set of protocols and algorithms provides extreme wireless robustness, capable of dealing with multiple interference sources as present in the 2.4 GHz band.
In addition, a wireless bi-directional data channel is available (e.g. to control the volume of the receiver from the transmitter).

The module integrates all functionality for a wireless digital audio connection, comprising:

- Wireless Audio Processor, DARR79
- 2.4 GHz radio
- Embedded Antennas
- Dual Antenna Connector
- Digital audio interfaces
- I^2C control interface
- Boot EEPROM (Only for Autonomous Receivers, optional)
- MCU (optional)
- 26 pins interface connector (FFC) for power, digital audio and control interface and GPIOs

1.2 DWAM79_D2D Block Diagram:



The DWAM79_D2D is used for both the Central Unit (CU, transmitter) and Mobile Unit (MU, receiver). The module is configured either through the I^2C interface, through the EEPROM or through the optional microcontroller (see here below).

The DWAM79_D2D holds an optional serial EEPROM (ST M24C64) or an optional microcontroller (Philips P89LPC920FDH). The EEPROM can be used in receiver units as a boot device where a microcontroller is not required. The microcontroller can run application software for more advanced applications. This yields full application flexibility in terms of configuration, data message transfer, GPIO management and link control.

1.3 Basic Features:

- Secure, wide band, scrambled digital 2.4GHz wireless link in the world-wide license exempt 2400-2483.5 MHz ISM-band.
- Digital audio:
  - uncompressed audio (44.1ksps or 48ksps, 16bit)
  - or optional proprietary low latency compression algorithm
  - up to 4 audio streams
- Low latency (configurable from 5…17ms)
- Advanced dedicated base band controller to provide an enhanced level of robustness against both in- and out of band interferers:
  - Microwave ovens
  - WLAN (802.11.x)
  - 2.4GHz cordless phones
  - Bluetooth (class I, II, III)
  - GSM telephones
  - DECT telephones
- In-room or multi-room usage (point to multi-point is also supported)
- Possibility to combine up to 3 CU's, yielding wireless audio network serving up to 12 audio streams
- I^2S and S/PDIF input/output
- Programmable digital audio gain
- Soft audio muting under poor link circumstances
- Bi-directional data channel
- Wirelessly accessible registers (e.g. RF channel switching, audio volume)
- Wirelessly accessible GPIO (e.g. user control switches, LED indicators)
- Automatically controlled receiver/transmitter antenna spatial diversity
- Automatic frequency allocation
- WLAN sniffer to detect WLAN frequency and to select non-interfering frequency
- Compliance with applicable European and US American laws, especially EN 300 328 and FCC Part 15.247
- I^2C control bus
- Efficient link quality monitoring
- Power Down Duty Cycle mode: If no link is established, modules (both TX and RX) will enter PDDC mode. In this mode the module periodically tries to re-establish the link maintaining minimum power consumption
- Pairing Function: All units in the same wireless audio network are provided with a 16 bit network ID, shielding the network from neighbor audio networks.

1.4 Example Applications

1. Wireless 4 Channel Audio System
   - High quality, uni-directional 4 channel audio link
   - Bi-directional data traffic

2. Wireless Stereo System
   - Add any number of speakers/headsets to tune in on wireless audio
   - High quality uni-directional 2-channel audio
   - Bi-directional data traffic
   - Multi-room, multi-speaker (point-to-multipoint) functionality

3. Wireless Headphone System
   - High quality, stereo uni-directional audio link with multi-room, multi-speaker functionality
   - Bi-directional data traffic, low power consumption receiver

4. Wireless Microphone System
   - High quality, mono uni-directional audio link
   - Bi-directional data traffic, low power consumption transmitter

System Specifications

ID	Parameter	Value	Unit	Remarks
RF Characteristics				
	RF frequency range	2400-2483.5	MHz	
	Number of RF channels	3		
Air framing				
	Addressing	12	Bit	
	Data message size	16 or 8	Byte	
	CRC	16, 24 and 32	Bit	Hybrid
Control				
	Control interface	I^2C		Compliant with the I2C protocol (slave), 0…400kbps. Base address 0x80, can be offset by A0 and A1 HW pins.
	Data Bandwidth	20	Kbps	Bi-directional wireless data channel
	Data latency	15	ms	Maximum
Link budget				
	Range indoor	> 50	m	Same room, no drop-outs from multi-path guaranteed
	Range line of sight	>100	m	Open Field
	Output power	16	dBm	Typical Value
Interference Robustness				
	Fixed frequency devices (e.g. WLAN, microwave oven)			Fully coexistent *)
	Frequency hopping devices (e.g. Bluetooth, 2.4GHz cordless phones)			Fully coexistent *)

**) Laboratory tests have verified coexistence with interference sources collocated. Exact ranges are scenario dependent (function of latency, output power, audio compression, etc.). A mix of interference sources is allowed. Interference of fixed frequency devices may result in the loss of one useable RF channel.*

Current Consumption/Power Supply (example application)				
	Supply voltage Typical	3.3	V	Regulated voltage
	Peak Power	380	mA	Peak power when transmitter is on.
	Power consumption of Disabled unit	25	mA	including 5 mA Microcontroller and 4 mA of regulator
Audio Interface				
	Available Interface Types	I^2S S/PDIF LRJ		
	Number of audio output channels on Mobile Unit	1, 2, 3 or 4		Per RF channel[3)]
	Number of audio input channels on Central Unit	1, 2, 3 or 4		Per RF channel[1)]
Operating Conditions				
	Min operating temp.	-10	^oC	
	Max operating temp.	70	^oC	
Audio Quality				
	Sample rate	44.1 or 48	ksps	
	Sample width	16	bit	24-bit is also supported on interface level (truncated)
	Latency	15.0	ms	Configurable from 5 to 17ms[4)].
	SINAD	99.7	dB	A-weighted, measured at S/PDIF interface, uncompressed audio
	THD (compressed audio)	0.3	%	Measured at S/PDIF interface
	THD (uncompressed audio)	0.003	%	Measured at S/PDIF interface
	Frequency response	0	dB	20Hz…22kHz (measured at S/PDIF interface)
Dimensions				
	Board dimensions	42x42	mm^2	

[3] For 3 or 4 audio channels, I^2S must be selected as audio interface
[4] Lower settings then 10ms are possibly at the expense of interference robustness.

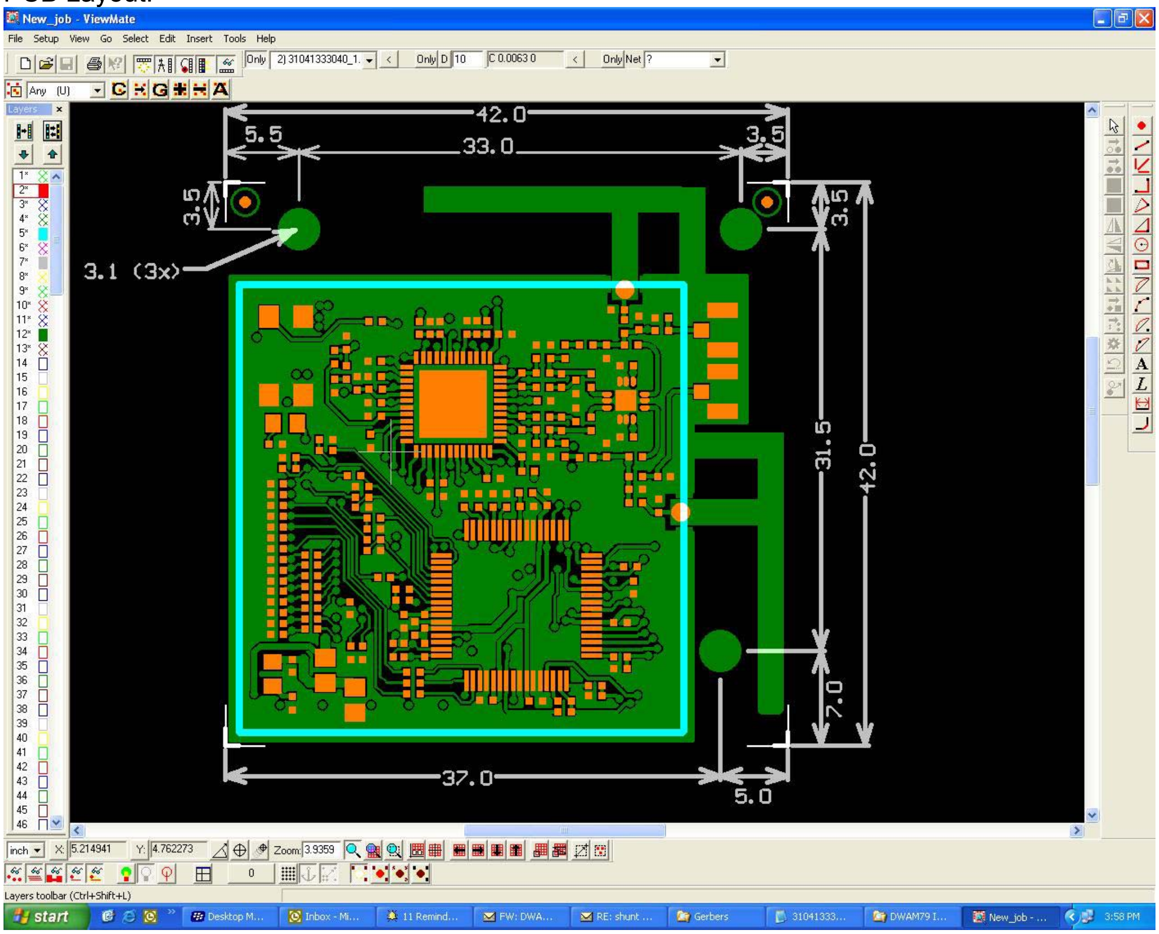
Estimated DWAM79_D2D Power consumption

Power consumption at 3.3 Volt of DWAM79_D2D	Compressed		Uncompressed	
	MU	CU	MU	CU
Headphone [NACK] 48.0kHz, 4 Audio Channels	55	130	80	233
Headphone [NACK] 48.0kHz, 2 Audio Channels	45	92	56	140
2 Speaker [ACK] 48 kHZ with 1 Audio channel	TBD		75-85	
2 Speaker [ACK] 48.0kHz	74-85	85-110	109-132	131-174
3 Speaker [ACK] 48.0kHz	85-100	100-130	128-160	160-210
3 Speaker [ACK] 48.0kHz	91-113	113-147	144-185	190-250

Note 1: Because the ACK application have Automatic power control these application have variable power consumption depending on range and packet error rate.

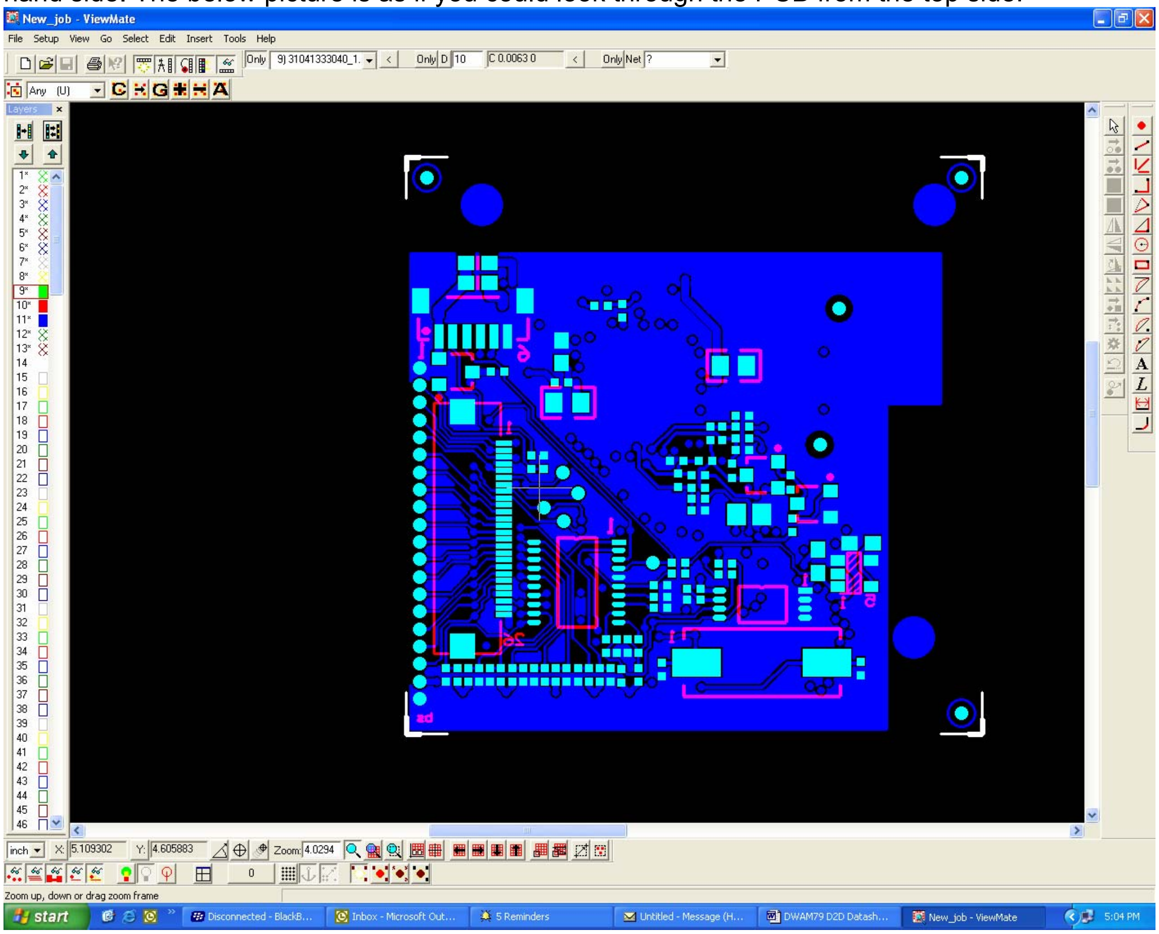
Note 2: The above Measurements are under un-interfered circumstances when retransmissions are required, current consumption will change (eg ACK And CU NACK @ 30 % -> 280mA and only MU NACK 110 mA when there is interference)

PCB Layout:



As depicted by the light blue line in the above picture, the PCB has a provision for a metal shield (optional).

The FFC connector is located on the bottom of the PCB in the lower left corner, positioned in the y-direction. Pin 26 is located closest to the corner of the board, with pin 1 in the middle of the left hand side. The below picture is as if you could look through the PCB from the top side:



1.5 Pinout 26 pin FFC Interface Connector

The type number of the FFC connector is 26-pin Molex 52689-2687 (0.5mm pitch). The pin listing is shown here below:

Pin Number	Pin Name	I/O	Description
1	SDOUT_A	Out	I^2S or S/P-DIF Out (port A)
2	SDIN_A	In	I^2S or S/P-DIF In (port A)
3	BCK	InOut	I^2S Bit Clock for ports A and B
4	GND	Ground	
5	LRCK	In/Out	I^2S Left Right Clock for ports A and B
6	SDOUT_B	Out	I^2S output data, port B
7	SDIN_B	In	I^2S input data, port B
8	I2C_SDA	InOut	Data pin of 2 wire serial bus
9	I2C_SCL	InOut	Clock pin of 2wire serial bus
10	RESN	In	Low Active Reset Pin
11	GPIO0_ASIC	InOut	Pin to control unit pairing function (ID learning) / GPIO 0 of DARR79
12	GPIO1_ASIC_LINK	InOut	Link Status Indicator/ GPIO 1 of DARR79
13	GPIO2_ASIC_INT	InOut	Low Level Interrupt pin. Requires external pull-up resistor./ GPIO_2 of DARR79
14	GPIO3_ASIC	InOut	Serial Async for test purposes/ GPIO 3 of DARR79
15	GPIO0_MCU	InOut	Only available for DWAM79_D2D with MCU
16	GPIO1_MCU	InOut	Only available for DWAM79_D2D with MCU
17	GPIO2_MCU	InOut	Only available for DWAM79_D2D with MCU
18	GPIO3_MCU	InOut	Only available for DWAM79_D2D with MCU
19	GPIO4_MCU	InOut	Only available for DWAM79_D2D with MCU
20	GPIO5_MCU	InOut	Only available for DWAM79_D2D with MCU
21	GPIO6_MCU	InOut	Only available for DWAM79_D2D with MCU
22	GPIO7_MCU	InOut	Only available for DWAM79_D2D with MCU
23	GND	Ground	
24	MCLK	In	11.2896 MHz /12.288 TTL input[6]
25	GND	Ground	
26	VCC_3V3	Power	Regulated 3.3V input

Please note, that the digital IO is CMOS 3V3 and not 5V compliant.

[6] Optionally, the audio clock may be derived from the RF crystal. In this configuration, this pin behaves as an output.

1.6 RF Connections

The DWAM79_D2D module has provisions (manufacturing options) for the use of the embedded PCB track antennas or external antennas through the use of 2 I-PEX coaxial RF connectors (for TX and RX diversity).

2 DWAM79_D2D Hardware Development

This section discusses module placement and integration.

2.1 Manufacturing Options

Standard, the DWAM79_D2D is equipped without microcontroller, without regulator and without EEPROM. This is the configuration that is advised. In case of special customer requirements, manufacturing options of the DWAM79_D2D provide for different configurations. In addition, the customer can choose between the use of the embedded (printed) antennas (default) or external antennas through the use of coaxial RF connectors (optional).

2.1.1 Microcontroller (Philips P89LPC920FDH)

The module has an optional microcontroller. This microcontroller can be used to configure the DWAM79_D2D at startup and run the customer application. MCU GPIO functions are accessible through the interface connector (see section 1.6).

Alternatively (as is standard supplied), the DWAM79_D2D holds no microcontroller. DWAM79_D2D initialization (and monitor/control functions) are through the I2C bus (see section 1.6).

There is no functional difference between a microcontroller on the DWAM79_D2D or on the application controller board; a microcontroller on the application controller board provides more freedom (choice of microcontroller, GPIO, etc.).

2.1.2 EEPROM (ST M24C64)

Standard, the DWAM79_D2D is not fitted with an EEPROM. For simple applications, where only very limited user control is required on the MU, the MU DWAM79_D2D may be equipped with an EEPROM, programmable through the I2C bus. This then holds the initialization values of the DWAM79_D2D that will be loaded at boot. The MU’s registers and GPIO can be wirelessly controlled from the CU if needed. Note that the CU always requires a microcontroller.

Alternatively (as is standard supplied), for such simple applications, an EEPROM may be placed on the application controller board. The DWAM79_D2D will read out the EEPROM contents through the I2C bus (see section 1.6).

There is no functional difference between an EEPROM on the DWAM79_D2D or on the application controller board; it may be considered, that since an EEPROM only makes sense for simple applications on an MU, that the EEPROM is placed on the application controller board, to have one module for all applications and MU/CU.

2.1.3 crystal configurations (44.1/48ksps)

Regardless of I2S master or slave mode, the audio clock signal must be supplied externally. In case of 48ksps applications, 12.288MHz is required and in case of 44.1ksps applications, 11.2896MHz.

2.1.4 Internal/external antennas

Standard, the module is equipped with embedded antennas. Optionally (where there is a requirement for a specific radiation pattern or antenna placement), external antennas may be used through coaxial RF connectors. This is a manufacturing option.

2.2 *Module Placement*

This section discusses the module placement; radiation pattern of the embedded antennas and general guide lines.

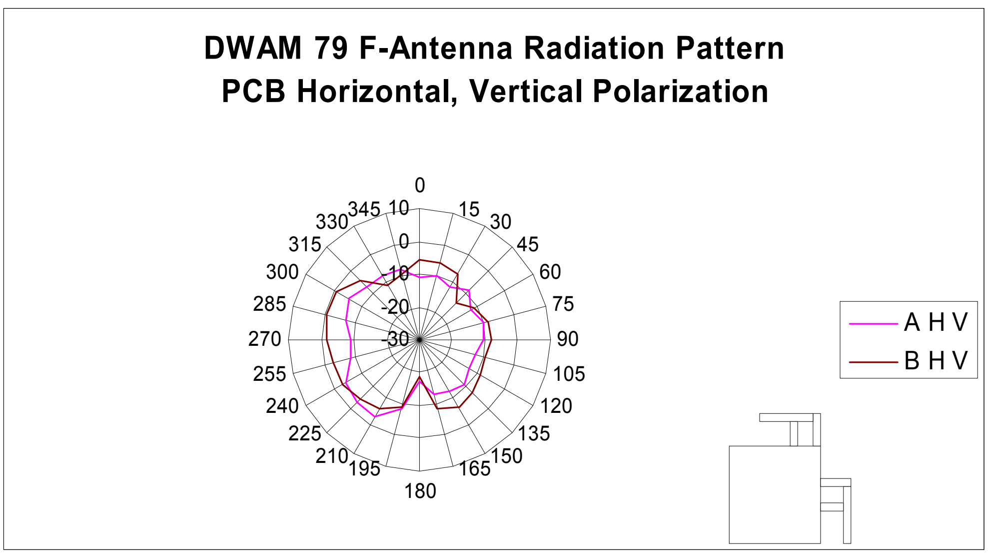
2.2.1 Horizontal PCB (internal antennas)

The DWAM79_D2D holds two embedded antennas, called A and B. Firstly, with the PCB in horizontal orientation, the radiation pattern is depicted in the lower right corner, in line with the angles in the plot. The legend is coded as follows:

X Y Z

X: antenna ID A/B
Y: PCB orientation H/V
Z: Polarization measured H/V

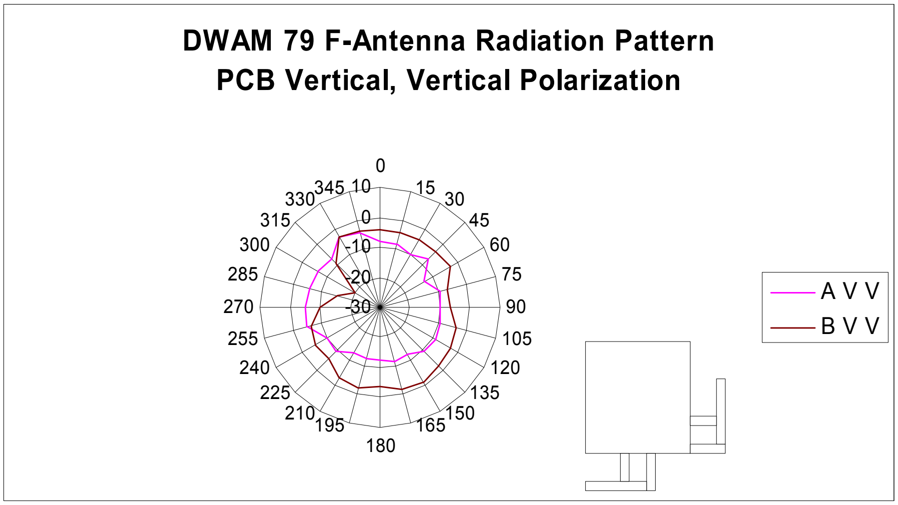
The antenna gain in directions 315 … to … 210, which covers 2/3 of the total pattern, is 5 to 10 dB less than the maximum antenna gain, on both antennas and both polarizations. The major dip at 180 degrees, is shared among both antennas. A horizontally placed PCB should preferably be placed with the flat-foil connection in the direction of the other party.

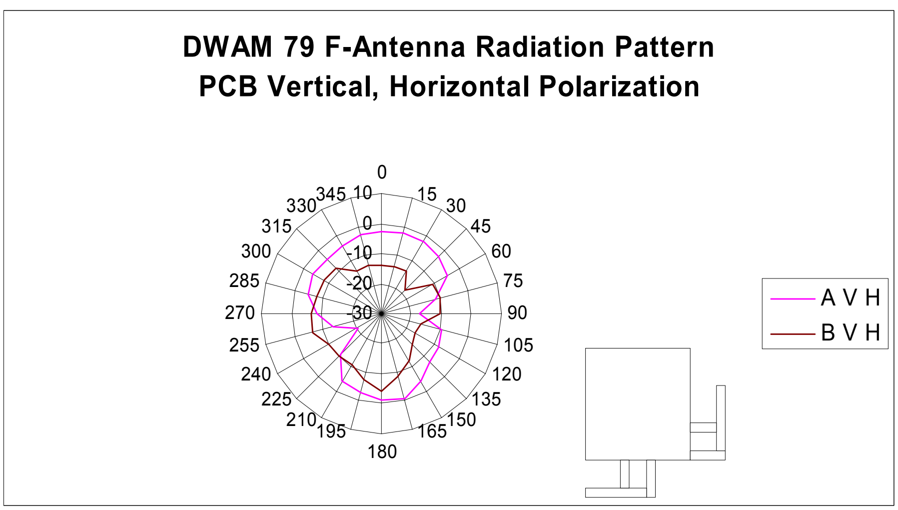


2.2.2 Vertical PCB (internal antennas)

A vertically mounted DWAM79_D2D has about 7dB more link budget than a horizontal placed one. The next two plots show that both antennas are quite nicely compatible, leading to a much more balanced radiation pattern than with a horizontal PCB; dips in one 'antenna' are compensated by the other.

Regarding the interpretation of direction, the depicted module is viewed at angle 0 as you view it now on paper or on the screen. For increasing angle, the measured direction moves clockwise around the module.





In conclusion: vertical mounting is preferred over horizontal mounting in terms of RF link budget.

2.2.3 General Module Placement Guide Lines (EMC coupling)

The module outputs typically 16dBm of RF power. This holds both for the CU and the MU (in NACK mode, the MU transmits when a packet is lost and in ACK the MU acknowledges receipt of each message by RF transmission). This RF energy may be received by the application controller board and rectified by analog non-linear components (e.g. coupling capacitors) and this may eventually result in audible artifacts. It is therefore important that the RF module (especially the antennas) is separated from the analog circuitry as much as possible.

2.2.4 Potential Antenna Issues

This section goes for the embedded antennas as well as the potential use of external antennas (manufacturing option)

- No ground plane of tracks must be placed on the application board underneath the DWAM79_D2D module
- Antennas must not be placed close to metallic objects
- Be careful not to place the wiring inside the finalized product close to the antennas
- Please note that final antenna tuning may be required of the final product for optimal antenna performance (due to antenna detuning by the enclosure and/or surrounding components)
- Do not use e metallic enclosure or metallized plastic if the antennas are internal
- Ensure that the enclosure is tested for low RF losses when the antennas are placed internally (an easy test is to measure the heating of the enclosure when put by itself in a microwave oven)

2.3 Crystal Configurations

TBD

2.4 Power Supply

2.4.1 General Power Supply Decoupling

The RF frame rate is in the audio frequency band. So the switching between TX and RX will cause a power supply ripple (because of the change in current between TX and RX mode) that is also in the audio frequency band. Therefore, it is important that the DWAM79_D2D power supply is isolated from the audio circuitry power supply.

Listed here below are some general guide lines:

- Use a dedicated power supply line for the module. This line feeds a dedicated 3.3V regulator and large decoupling capacitor.
- Consider the Pi-network for power supply decoupling from the regulator to the module (large capacitor to ground, series bead inductor, capacitor to ground).
- Isolate the control loop of the application board regulator from this 3.3V power supply domain
- Use a very short and solid ground connection from the star point of the power supply to the module.
- Isolate the module's ground from the analog ground.
- Use low ESR capacitors (e.g. Nichicon HDM)

With the above guide lines, it should be possible to suppress the switching peaks to well over 110dB below the full scale output.

2.4.2 MTXG Register

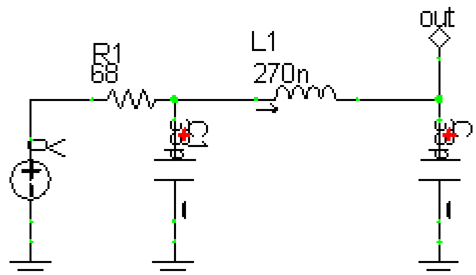
The difference in current consumption between TX and RX (see preceding section) can also be lowered if e.g. the RF link budget exceeds what is required by the application.

If the link budget is far sufficient, then the RF output power can be lowered, thereby reducing the current switching difference. This can be done with the MTXG register (see the programming model for details) and should be determined experimentally, taking into account all distance related performance aspects of the system.

2.5 Digital IO filtering

2.5.1 MCLK filtering

The audio clock signal runs over the flat foil cable to the DWAM79_D2D. The harmonics can easily radiate and exceed the regulatory limits if the drive strength is too strong and/or cable and/or PCB trace lengths are too long. To overcome this, the audio clock signal can be filtered at the source (i.e. at the crystal oscillator itself) by a simple filtering circuit such as depicted here below:



2.5.2 I2S Bus

The I2S bus signals are transported over the FFC. To overcome potential radiation problems, it is advised that the bus is filtered on the application board with a resistor array (e.g. 33…68Ohm) and small valued (e.g. 10pF) capacitors.