“ЖУРНАЛ РАДИОЭЛЕКТРОНИКИ” N 5, 2009

SYSTEM SIMULATION OF WIMAX OFDMA- MIMO DOWNLINK CHANNEL FOR WIRELESS APPLICATIONS

K.Meena alias Jeyanthi[1], Dr.A.P.Kabilan[2],

[1] Department of Electronics and communication,PSNACET,Dindigul.

[2]Principal,Chettinad college of engineering & technology, Karur

Received May 8, 2009

IEEE 802.16 is an emerging global broadband wireless access standard capable of delivering multiple megabytes of shared data throughput supporting fixed, portable and mobile operations. WiMAX represents a scalable and cost-effective solution to offer wider area coverage, improved performance in terms of QOS, service continuity in case of terrestrial network failure and long range user mobility. The ever increasing demand of OFDMA and MIMO, plays a major role in multiuser and multicarrier frame work. We propose a suboptimal, subcarrier allocation criteria for OFDMA-MIMO systems. The computational complexity grows linearly with the number of users and the number of sub carriers. Numerical results are presented to compare the two sub carrier allocation criteria with the optimal criterion. It is observed that BER and FER approaches rapidly for lower energy to noise ratio.

Keywords: WiMAX, MIMO, OFDMA, Bit error rate and Frame error rate, CCDF.

МОДЕЛИРОВАНИЕ СИСТЕМЫ НИСХОДЯЩЕГО КАНАЛА WIMAX OFDMA-MIMO ДЛЯ БЕСПРОВОДНЫХ ПРИЛОЖЕНИЙ

К. Мина Джеянти[1], А. П. Кабилан[2]

[1]Факультет электроники и связи колледжа PSNACET, Диндигул, Индия
[2]Инженерно-технологический колледж, Карур, Индия

Получена 8 мая 2009 г.

Стандарт IEEE 802.16 - это стандарт широкополосного беспроводного доступа, допускающий мультимегабайтную пропускную способность данных с общим доступом. WiMAX представляет собой масштабируемое и экономичное решение для расширения области охвата, улучшения производительности, обеспечения бесперебойности связи в случае разрыва наземных сетей и большой диапазон мобильности пользователя. Требование OFDMA и MIMO играет основную роль в среде с многими пользователями и несколькими несущими. В работе предлагается оптимальный критерий для размещения субнесущей для системы OFDMA-MIMO. Сложность вычислений линейно растет с числом пользователей и числом поднесущих. Приводятся численные результаты для сравнения критерия размещения двух субнесущих с оптимальным критерием. Обнаружено, что частота ошибок по битам и частота ошибок по фреймам быстро достигается при более низком отношении энергия-шум.

Ключевые слова: передача данных, WiMAX, MIMO, OFDMA, обработка сигналов, частота ошибок по битам, частота ошибок по фреймам, CCDF.

1. Introduction

WiMAX is a world wide interoperability microwave access is a telecommunication technology that provides wireless data in a variety of ways and its name was created by WiMAX forum. In several countries, manufacturers, operators and public authorities look at WiMAX system as a viable technology to fill the “digital divide”, providing broadband services mainly in suburban and rural areas, but also in densely populated areas[1]. WiMAX is a wireless digital communication system, also known as IEEE 802.16 or wireless MAN that is intended for wireless “metropolitan area networks”. WiMAX can provide broadband wireless access (BWA) up to 30 miles (50 km) for fixed station and 3 to 10 miles (5-15 km) for mobile stations. WiMAX provides up to 70Mbps per station for cells with radii of several kilometers. Traditional wireless system uses single antenna for transmission and single antenna for reception, called single input and single output systems(SISO).In recent years, significant progress has been made in the field of wireless communication, that use multiple antennas for transmission and reception, called multiple input and multiple output(MIMO)[3].

1.1 Multiple antenna system

It uses the advantage of diversity in wireless communication. The channels are affected by rayleigh fading. Multiple antennas at the transmitter and receiver can provide diversity gain and increased data routes through the space time signal processing. Adaptive array provides high antenna gain for extended battery life, extended range, high throughput, multipath diversity gain for improved reliability including more robust operation of services and also provides interference suppression, reduced interference, reduced interference in other systems on transmission,high link capacity through the use of MIMO with spatial multiplexer[4].

1.2 MIMO

MIMO stands for Multiple Input and Multiple Output, and refers to the technology where there are multiple antennas at the base station and multiple antennas at the mobile device. Typical usage of multiple antenna technology includes cellular phones with two antennas, laptops with two antennas.OFDMA and MIMO integrated to offer the benefits of both systems simplicity and high performance.Beam forming MIMO, Standards-compatible techniques to improve the range of existing data rates using transmit and receive beamforming, Also reduces transmit interference and improves receive interference tolerance.Spatial multiplexing MIMO,allows even higher data rates by transmitting parallel data streams in the same frequency spectrum. Figure 1 shows the simple MIMO system model.

1.3 MIMO Techniques in WiMAX

WiMAX implementations that use MIMO technology have become important. The use of MIMO technology improves the reception and allows for a better reach and rate of transmission. The implementation of MIMO also gives WiMAX a significant increase in spectral efficiency. A simple MIMO system shown in figure 1 shows 2x2 antenna system. Nearly orthogonal signatures can be constructed to simultaneously transmit to multiple users at the same bandwidth or to transmit to distinct data rates on the same bandwidth but with differing spatial signatures.let the input data be serial data s1,s2, transmitted by two antennas through the channel.The test vectors are generated using channel matrix and received by two antennas to produce two distinct received signals r1 and r2.This is explained in detail in the section 2.3.

1.4 Modulation scheme

Single frequency signal is always on at the same phase and amplitude conveys no information. To transmit the data, a sinusoidal signal must change with time, the signal must be modulated. The different modulation standards are introduced starting from the on off keying to the quadrature modulation. Code rate is a type information rate, states that the percentage of useful information content in a signal. If a coder generates 'n' bits total data, and 'k' bits of useful information, the code rate is 'k/n'.

1.5 Benefits and challenges:

The WiMAX standard depends upon a grand-request access protocol that doesn't allow data collisions and therefore uses the available bandwidth more effectively. Other characteristics of WiMAX standards includes higher quality of service,full support for WMAN service, WiMAX support more users and deliver faster data rates at longer distances. As more users join they must share the aggregate bandwidth and their individual throughput decreases linearly. This capability is termed “efficient multiple access”. Smart antenna support-Smart antennas are being used to increase spectral density and to increase signal to noise ratio for WiMAX. Because of performance and technology, WiMAX standards support several adaptive smart antenna types, including Receive spatial diversity antennas, Simple diversity antennas, beam steering antennas, Beam forming antennas.

2. Orthogonal Frequency division Multiplexing

All the modulation schemes are single carrier modulation techniques. Single carrier modulation are versatile and relatively simple to implement. Those schemes have some fundamental limitations in a wireless link. In a real world transmission, the concept of multipath, that is various sorts of obstacles may exist that reflect the signal providing alternatives to the direct path. OFDM has been proposed for very high data rate and provides parallelism, allowing 10 fold increase in the transmission delay allowed before serious multipath distortion occurs[7].

2.1 OFDM transmitter

In the OFDM transmission system, the OFDM symbol, each data set is converted into a complex number of decreasing amplitude and phase of the subcarrier and that complex number becomes the complex amplitude of the corresponding subcarrier[5]. In Figure 2, the inverse FFT convert the frequency spectrum into a sequence of time samples. This set of numbers is read out serially and assigned to successive time slots.The resulting complex numbers for signal versus time are converted into a pair of voltages by an ADC. The real part determines the Inphase or I channel and the imaginary part determines the quadrature or Q channel. These I and Q voltages are multiplied, by a cosine and sine at the center frequency[7]. The received symbol is demodulated in a similar fashion. Figure 2 shows how the data is mapped and transmitted in a channel and received in a OFDM system.

2.2 OFDM reception

OFDM symbol is quite complex, for a modest number of subcarriers. As the number of sub carriers grow large, the few symbols with all the subcarriers in phase grow increasingly rare as a percentage of the possible symbols. The received signal is demodulated, processed and mapped on QAM. Thus the output resembles the input.

2.3 System model

Test bench is simulated using Agilent's ADS2008 module. The RF source is designed to provide the signal strength of 10dBm at a center frequency of 2.305GHz for bandwidth of 10MHz. The system is simulated for 2x2 antenna. The RF signal is passed through MIMO channel. The system is modeled as OFDMA based on IEEE 802.16e design information. It is very important in the information theory study, the channel capacity of the wireless system. MIMO channel capacity is modeled as follows, there are m-number of transmitting antenna and n-receiving antennas.

The receives signal, $y(k) = H(k)x(k) + I(k) + z(k)$, (1)

y(k)-is nx1 received signal vector at time constant k,

$$y(k) = [y_1(k) y_2(k) y_3(k) y_4(k) \dots\dots\dots\dots y_n(k)]^H, \tag{2}$$

x(k)-is mx1 received signal vector at time constant k,

$$x(k) = [x_1(k)x_2(k)x_3(k)x_4(k)..........x_m(k)]^H \ , \qquad (3)$$

H(k) is nxm channel gain matrix at time instant k,

$$H(k) = \begin{bmatrix} h_{11}(k)h_{12}(k)h_{13}(k).............h_{1m}(k) \\ h_{21}(k)h_{22}(k)h_{23}(k).............h_{2m}(k) \\ . \\ . \\ . \\ h_{n1}(k)h_{n2}(k)h_{n3}(k).............h_{nm}(k) \end{bmatrix}, \qquad (4)$$

noise vector, $Z(k) = [z_1(k)z_2(k)z_3(k)...........z_n(k)]^H$

Interference, $I(K) = [I_1(k)I_2(k)I_3(k)..........I_k(k)]$

$$I(k) = H_I(k)x_I(k) \qquad (5)$$

$$y(k) = H(k)x(k) + H_I(k)x_I(K) + z(k) \ , \qquad (6)$$

$$y(k) = H(k)x(k) + w(k) \ , \qquad (7)$$

channel capacity, $C = B\log_2\left[\det\left[I + \frac{P_i HH^H}{\sigma_w{}^2}\right]\right]$, (8)

H channel matrix, P_i , i=1,2, ….λ- eigen value $\lambda_1 > \lambda_2 > \lambda r$.

3. BER & PER Measurements

The most commonly encountered ratio is the bit error ratio (BER) - also sometimes referred to as bit error rate *i.e.*, the number of erroneous bits received divided by the total number of bits transmitted.Packet Error Rate (PER) is used to test the performance of an access terminal's receiver. In performing the PER measurement, the test set, it always operates with 100% packet activity, means that all slots contain Forward Traffic Channel or Control Channel packets (data). Test bench is based on a modulation technique WMAN IEEE802.16e OFDMA for transmitter and receiver .It has the following features: Top-level baseband signal sources and RF signal source for downlink and uplink were provided. The system is modeled in the basis of TDD/FDD frames for downlink and uplink, it has 512,1024 &2048 FFT sizes, Channel coding is CC(Convolution coding) and CTC(Convolution turbo coding),STC/MIMO with two antenna source for both the uplink & downlink, Collaborative MIMO(SM) source with one transmit antenna for uplink signal.

Top-level baseband receivers and RF receivers for downlink and uplink were also developed. The functionalities are as follows: 512, 1024, 0r 2048 FET sizes with variable bandwidths, CC decoding with soft decision(with channel state information(CSI)),CTC decoding with soft decision(with channel state information(CSI)),STC/MIMO decoding(with ZF and MMSC). The figure 3 shows bit error rate and frame error rate of 2x2 MIMO channel operated at a center frequency of 2.305GHz with the FFT size of 1024 and the packet length is 100 bytes. From the figure 3 ,64QAM shows the better performance than other modulation schemes. The following table shows the code rate and bits per symbol for the different modulation schemes.

Table.1 Comparison of code rate and bits/symbol for various modulation scheme

Modulation	Code rate	Bits/symbol
QPSK	½	0

QPSK	¾	1
16 QAM	½	2
16 QAM	¾	3
64 QAM	½	4
64 QAM	2/3	5
64 QAM	¾	6

4. CCDF Measurements

CCDF curves provide the peak to average power data needed by component designers. This provides the power characteristics of 3G signals. This shows how much time the signal spends at or above a given power level. In the figure 4 , the peak to average power reaches 9.056dB.

The figure 5 shows that the number of tones increases**,** the channel resembles the AWGN curve. This becomes an important application of Noise power ratio measurements(NPR).The RF peak power for downlink signal is 9.055dB.

5. Waveform and spectrum Measurements

The model is designed in the ADS momentum 2008 for the IEEE 802.16e WMAN. Two signals analyzed in the MIMO channel, CCDF waveform is analyzed for various modulation schemes. The model is created for WMAN uplink and downlink channel for OFDMA system shown in the figure 5 & 6.

6. Conclusion

The proposed implementation system is a key enabler for high capacity data services, which is fundamental to success for WiMAX .It has been shown that multiple input and multiple output antenna systems offer spectral efficiency significantly higher than values reached in conventional radio systems. MIMO system can solve the problem of limited bandwidth. The competitive technology to MIMO is OFDMA. It is preferred over a single carrier solution due to lower complexity of equalizers for high delay spread channels or high data rates. The system has improved quality throughput, improved frequency spectrum utilization and the system shows the processing bandwidth of 1.25 to the maximum of 10MHz for different modulation schemes like BPSK,QPSK,QAM,OFDM,OFDMA.

REFERENCES

[1] www.WiMAX.forum.org.

[2] S.Chandran, "Adaptive antenna arrays, Trends and communication",springer International Edition,2008.

[3] Jeffrey H.Reed, "Software defines radio", Pearson Education,2006.

[4] George Tsoulos, "Adaptive antennas and MIMO systems for Mobile communications",Wiley IEEE Press,January 2001,pp. 3-26.

[5] Wolfgang Utschick and Pedro Tejera, "The spatial Dimension in wireless multicarrier communications' springer International Edition,2008,pp.29-45.

[6] S.Catreux,P.F.Driessen,L.J.Greenstein, "Attainable throughput of an intreference limited multiple-input multiple-output(MIMO) cellular system",IEEE Trans.communication,vol.49,no.8,pp.1307-1311,Aug.2001.

[7] Z.Liu,G.B.Giannakis,S.Barbarossa and A.Scaglione,'Transmit antenna space time block coding for generalized OFDM in the presence of unknown multipath", IEEE Journal on Selected Areas in communications, vol.19, no.7,pp.1352-1364,July 2001.

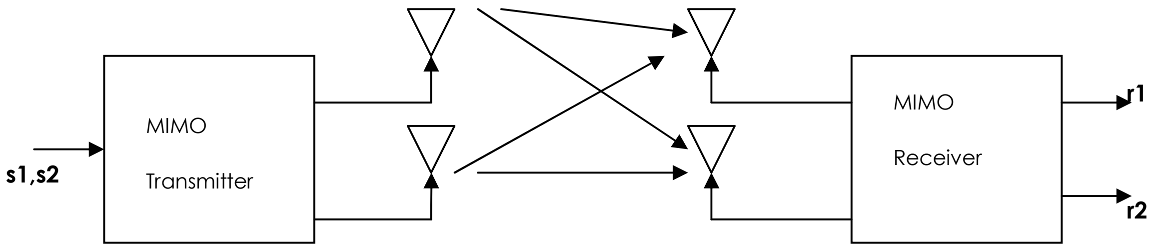


Figure.1 MIMO system

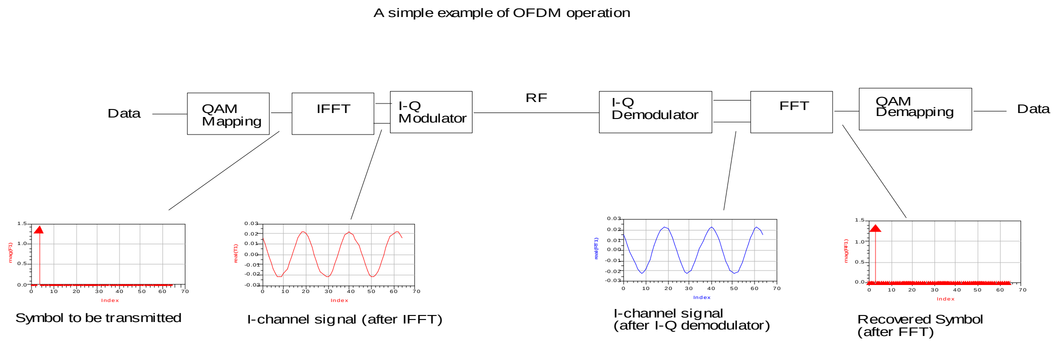


Figure. 2 Operation of OFDM system

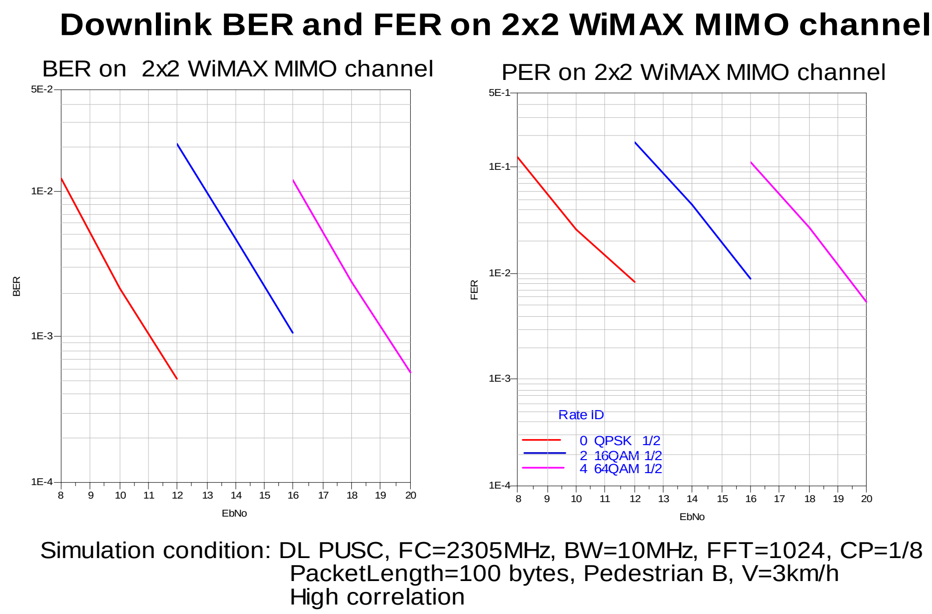
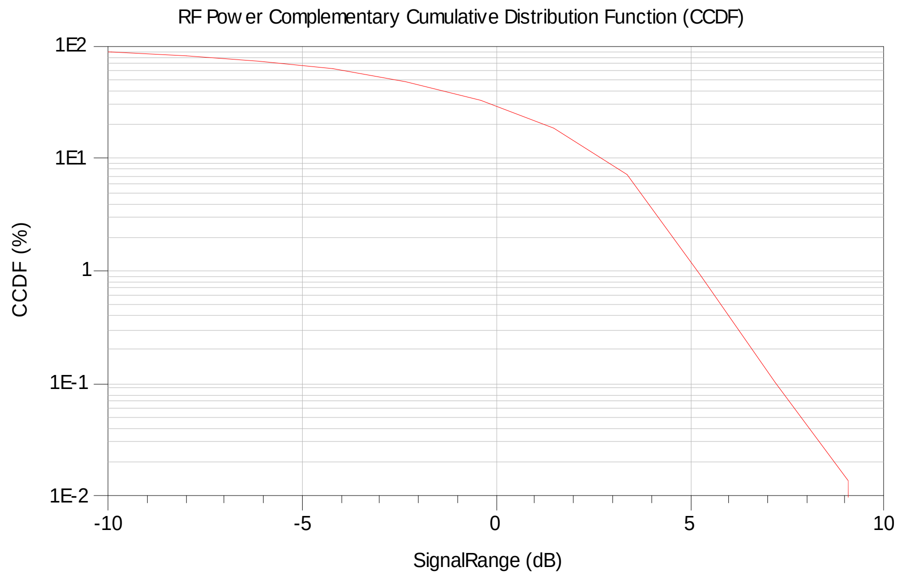


Figure.3 Measurement of BER & FER



PeakPow er_dBm	MeanPow er_dBm	RF_Peak_to_Avg_dB
-0.449	-9.505	9.056

Figure.4 CCDF Measurement

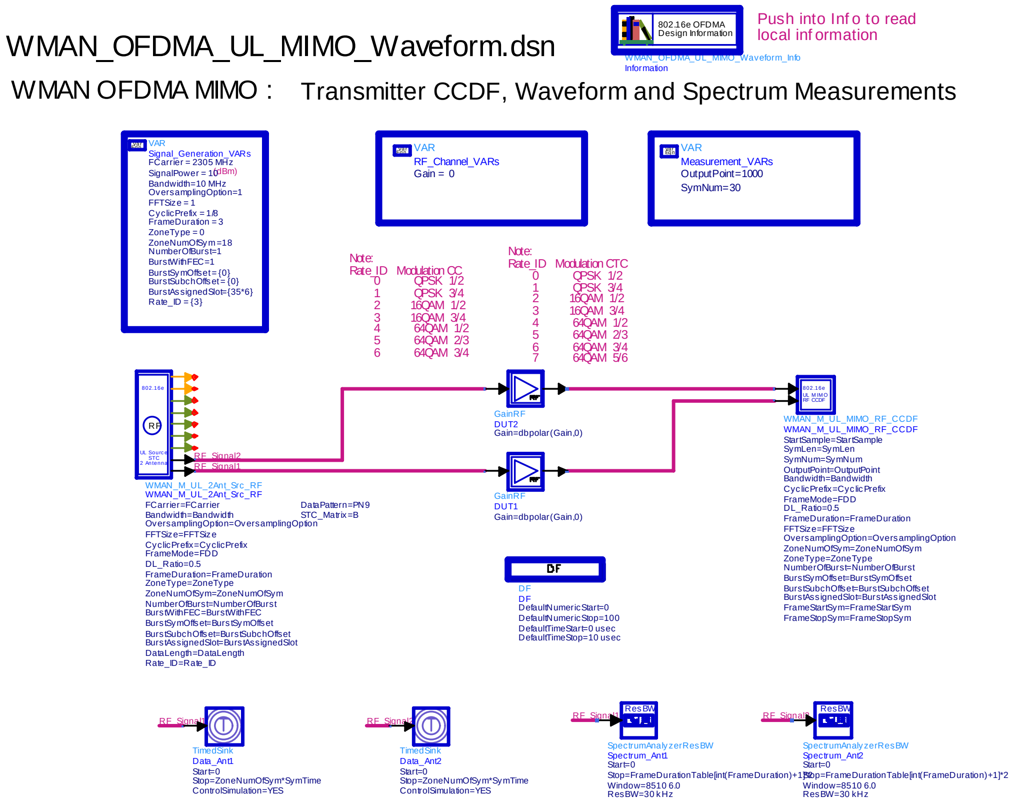


Figure.5 Uplink model for WMAN-OFDMA

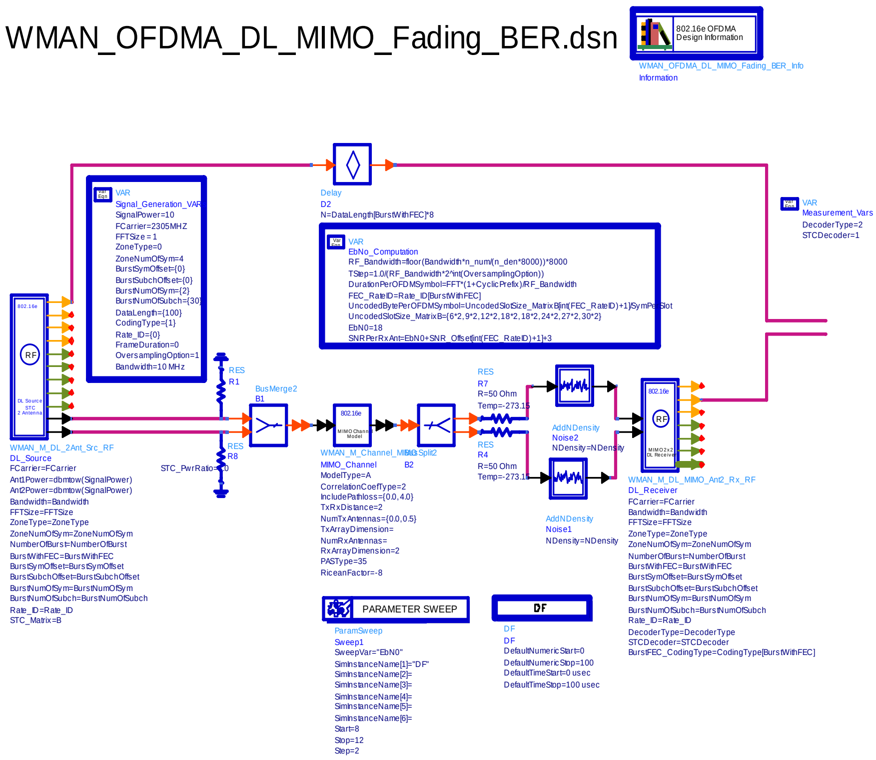


Figure 6 Downlink for WMAN-OFDMA