IN THE UNITED STATES DISTRICT COURT
FOR THE NORTHERN DISTRICT OF TEXAS
DALLAS DIVISION

ZAVALA LICENSING LLC,	§	
	§	
Plaintiff,	§	Case No:
	§	
vs.	§	PATENT CASE
	§	
KEYSIGHT TECHNOLOGIES, INC.,	§	JURY TRIAL DEMANDED
	§	
Defendant.	§	
	§	

COMPLAINT

Plaintiff Zavala Licensing LLC ("Plaintiff" or "Techno") files this Complaint against Keysight Technologies, Inc. ("Defendant" or "Keysight") for infringement of United States Patent No. 6,684,086 (hereinafter "the '086 Patent").

PARTIES AND JURISDICTION

1. This is an action for patent infringement under Title 35 of the United States Code. Plaintiff is seeking injunctive relief as well as damages.

2. Jurisdiction is proper in this Court pursuant to 28 U.S.C. §§ 1331 (Federal Question) and 1338(a) (Patents) because this is a civil action for patent infringement arising under the United States patent statutes.

3. Plaintiff is a Texas limited liability company with its office address at 15922 Eldorado Pkwy, Ste 500, Frisco, TX 75035.

4. On information and belief, Defendant is a Delaware Corporation with a principal address of 1400 Fountaingrove Pkwy, Santa Rosa, CA 95403.

5. On information and belief, this Court has personal jurisdiction over Defendant

because Defendant has committed, and continues to commit, acts of infringement in this District, has conducted business in this District, and/or has engaged in continuous and systematic activities in this District.

6. On information and belief, Defendant's instrumentalities that are alleged herein to infringe were and continue to be used, imported, offered for sale, and/or sold in this District.

VENUE

7. Venue is proper in this District pursuant to 28 U.S.C. § 1400(b) because Defendant is deemed to reside in this District. Alternatively, acts of infringement are occurring in this District and Defendant has a regular and established place of business in this District at 1220 E Campbell Rd, Richardson, TX 75081.

COUNT I
(INFRINGEMENT OF UNITED STATES PATENT NO. 6,684,086)

8. Plaintiff incorporates paragraphs 1 through 7 herein by reference.

9. This cause of action arises under the patent laws of the United States and, in particular, under 35 U.S.C. §§ 271, *et seq*.

10. Plaintiff is the owner by assignment of the '086 Patent with sole rights to enforce the '086 Patent and sue infringers.

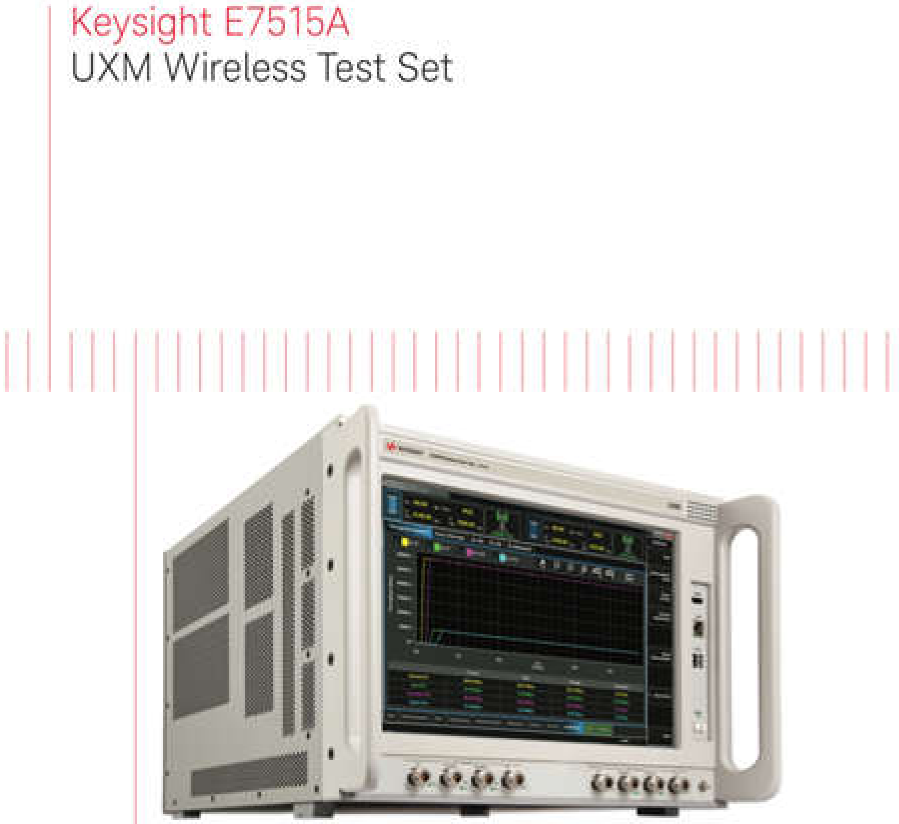
11. A copy of the '086 Patent, titled "Radio Base Station Device and Radio Communication Method," is attached hereto as Exhibit A.

12. The '086 Patent is valid, enforceable, and was duly issued in full compliance with Title 35 of the United States Code.

13. On information and belief, Defendant has infringed and continues to infringe one or more claims, including at least Claims 1 and 9, of the '086 Patent by making, using, importing, selling, and/or offering for sale radio base station equipment and systems, which are

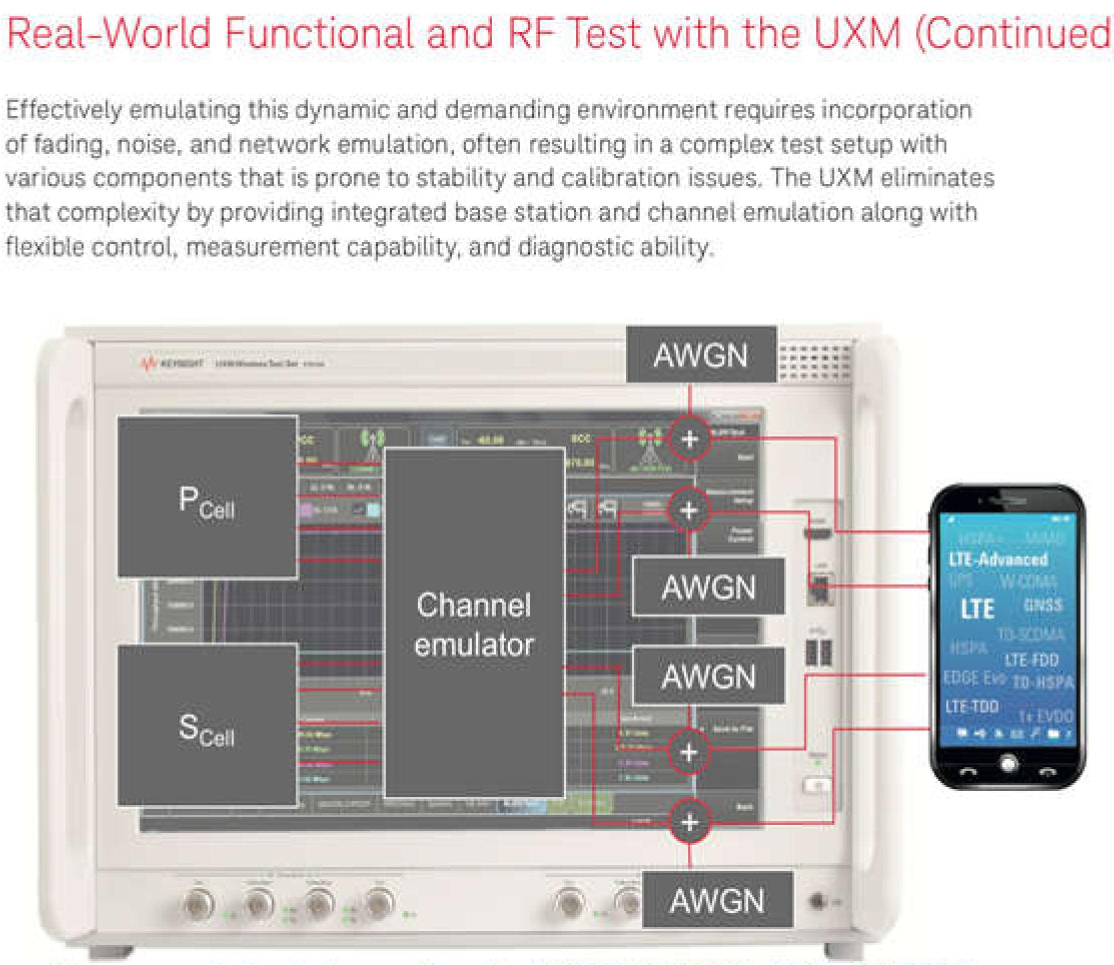
covered by at least Claims 1 and 9 of the ‘086 Patent. Defendant has infringed and continues to infringe the ‘086 patent directly in violation of 35 U.S.C. § 271.

14. Defendant sells, offers to sell, and/or uses radio base station equipment including, without limitation, the Keysight E7517A UXM Wireless Test Set, and any similar products (“Product”), which infringe at least Claims 1 and 9 of the ‘086 Patent. The Product comprises a radio base station apparatus (e.g., an LTE base station). As an LTE Base Station, the Product complies with the LTE Release 8 Standard. Certain claim elements are illustrated in the publicly available information regarding the Product, as shown below:



Keysight E7515A
UXM Wireless Test Set

https://literature.cdn.keysight.com/litweb/pdf/5992-0149EN.pdf?id=2523327



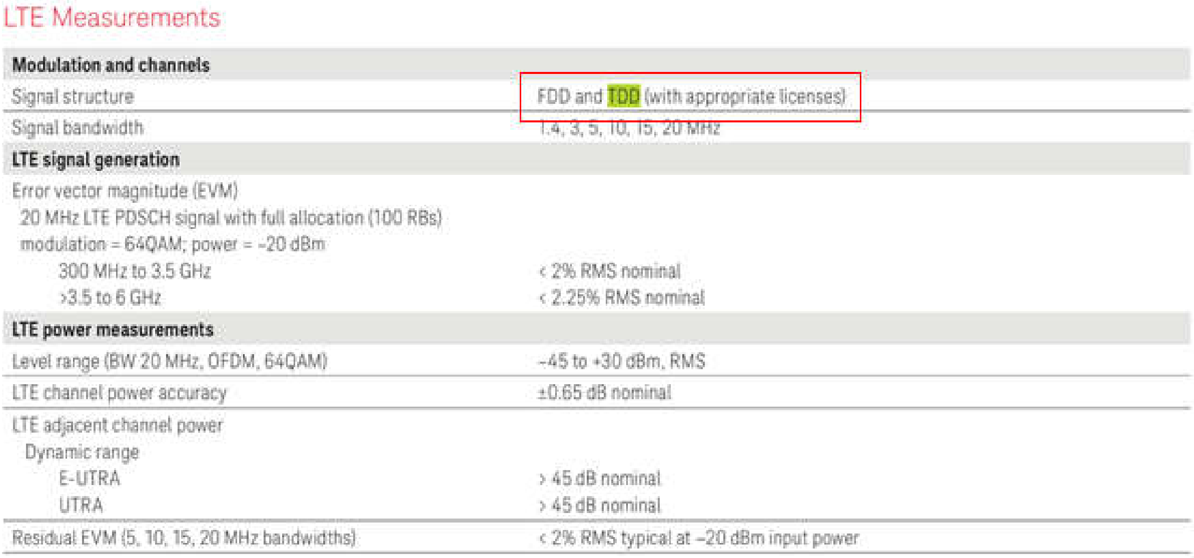
Real-World Functional and RF Test with the UXM (Continued)

Effectively emulating this dynamic and demanding environment requires incorporation of fading, noise, and network emulation, often resulting in a complex test setup with various components that is prone to stability and calibration issues. The UXM eliminates that complexity by providing integrated base station and channel emulation along with flexible control, measurement capability, and diagnostic ability.

https://literature.cdn.keysight.com/litweb/pdf/5992-0149EN.pdf?id=2523327

15. The Product comprises an estimation section (e.g., a processing block) that estimates arrival directions of receiving signals (e.g., direction of received uplink signal) from a plurality of communication terminals (e.g., mobiles, smartphones, tablets, etc.). The Product is configured to utilize TM7 Adaptive Beamforming as defined by the LTE Release 8 Standard. Base Stations capable of TD/TDD LTE must support TM7 Beamforming. This mode of beamforming uses UE-specific reference signals in order to determine beamforming weightings. To do so, a system utilizing TM 7 determines the Direction of Arrival (DOA) of a UE uplink signal and utilizes said DOA to calculate appropriate beamform weightings. In order to calculate beamform weightings based on the DOA of uplink signals sent by UE Devices, there must be

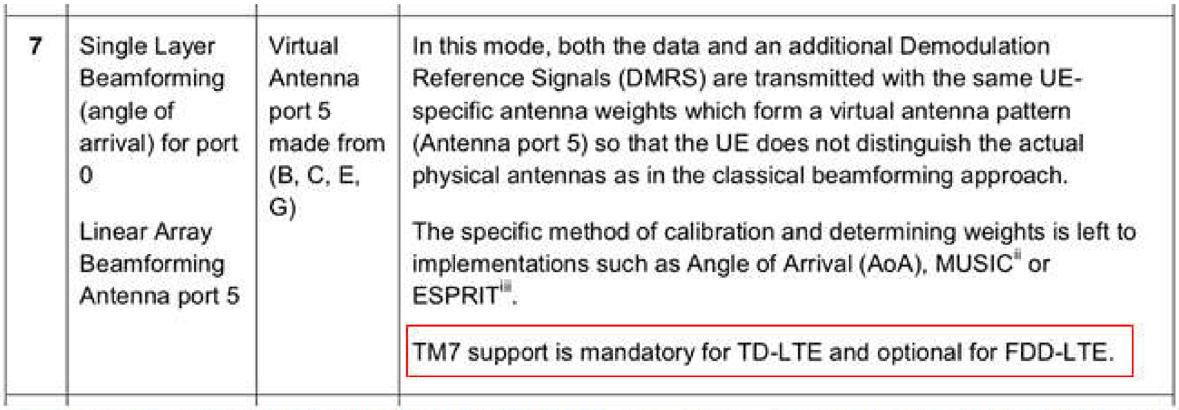
some form of processing block within the accused product. These and other elements are illustrated in the publicly available information regarding the Product, as shown in connection with the above allegations and as further shown below.



LTE Measurements

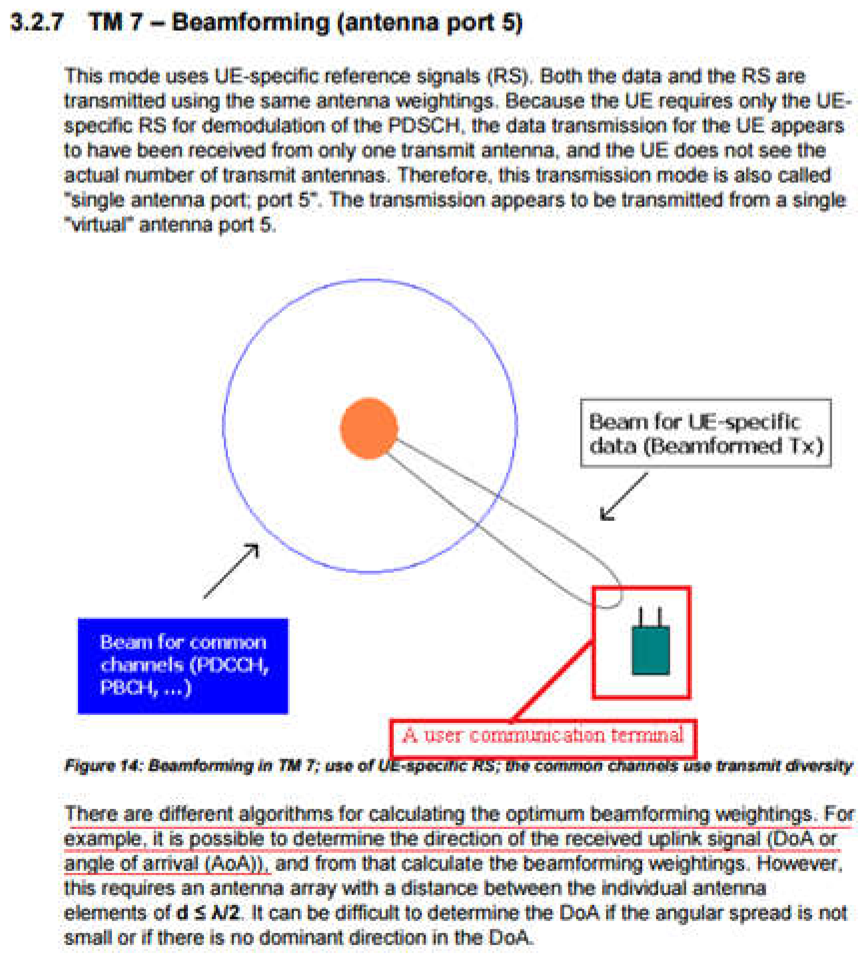
Modulation and channels	
Signal structure	FDD and TDD (with appropriate licenses)
Signal bandwidth	1.4, 3, 5, 10, 15, 20 MHz
LTE signal generation	
Error vector magnitude (EVM) 20 MHz LTE PDSCH signal with full allocation (100 RBs) modulation = 64QAM; power = -20 dBm	
300 MHz to 3.5 GHz	< 2% RMS nominal
>3.5 to 6 GHz	< 2.25% RMS nominal
LTE power measurements	
Level range (BW 20 MHz, OFDM, 64QAM)	-45 to +30 dBm, RMS
LTE channel power accuracy	±0.65 dB nominal
LTE adjacent channel power Dynamic range	
E-UTRA	> 45 dB nominal
UTRA	> 45 dB nominal
Residual EVM (5, 10, 15, 20 MHz bandwidths)	< 2% RMS typical at -20 dBm input power

https://literature.cdn.keysight.com/litweb/pdf/5991-4634EN.pdf?id=2490181



7	Single Layer Beamforming (angle of arrival) for port 0 Linear Array Beamforming Antenna port 5	Virtual Antenna port 5 made from (B, C, E, G)	In this mode, both the data and an additional Demodulation Reference Signals (DMRS) are transmitted with the same UE-specific antenna weights which form a virtual antenna pattern (Antenna port 5) so that the UE does not distinguish the actual physical antennas as in the classical beamforming approach. The specific method of calibration and determining weights is left to implementations such as Angle of Arrival (AoA), MUSIC[ii] or ESPRIT[iii]. TM7 support is mandatory for TD-LTE and optional for FDD-LTE.

http://www.5gamericas.org/files/4614/0622/2152/MIMO_and_Smart_Antennas_July_2013_FINAL.pdf



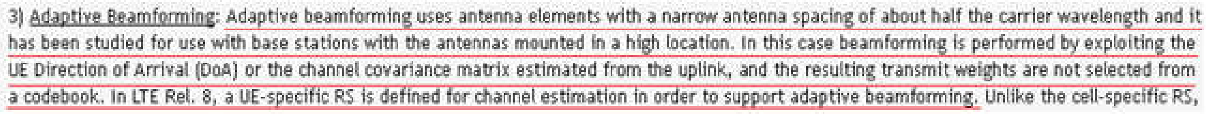
3.2.7 TM 7 – Beamforming (antenna port 5)

This mode uses UE-specific reference signals (RS). Both the data and the RS are transmitted using the same antenna weightings. Because the UE requires only the UE-specific RS for demodulation of the PDSCH, the data transmission for the UE appears to have been received from only one transmit antenna, and the UE does not see the actual number of transmit antennas. Therefore, this transmission mode is also called "single antenna port; port 5". The transmission appears to be transmitted from a single "virtual" antenna port 5.

Figure 14: Beamforming in TM 7; use of UE-specific RS; the common channels use transmit diversity

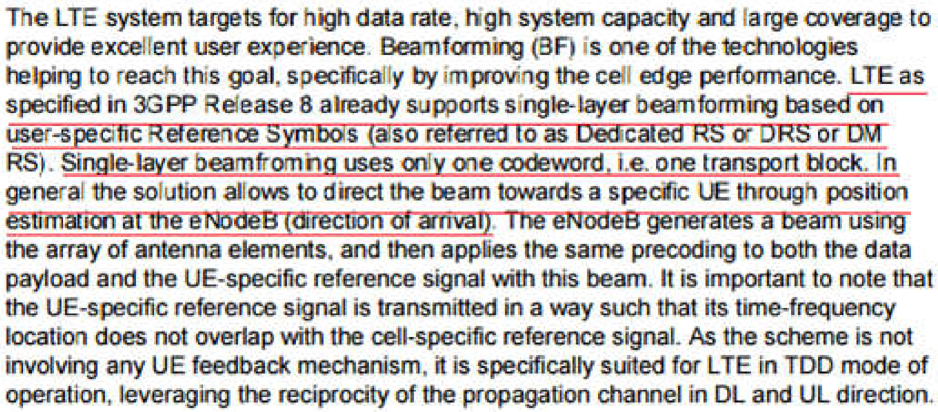
There are different algorithms for calculating the optimum beamforming weightings. For example, it is possible to determine the direction of the received uplink signal (DoA or angle of arrival (AoA)), and from that calculate the beamforming weightings. However, this requires an antenna array with a distance between the individual antenna elements of $\mathbf{d \leq \lambda/2}$. It can be difficult to determine the DoA if the angular spread is not small or if there is no dominant direction in the DoA.

http://www.3g4g.co.uk/Lte/LTE_WP_1110_RandS.pdf



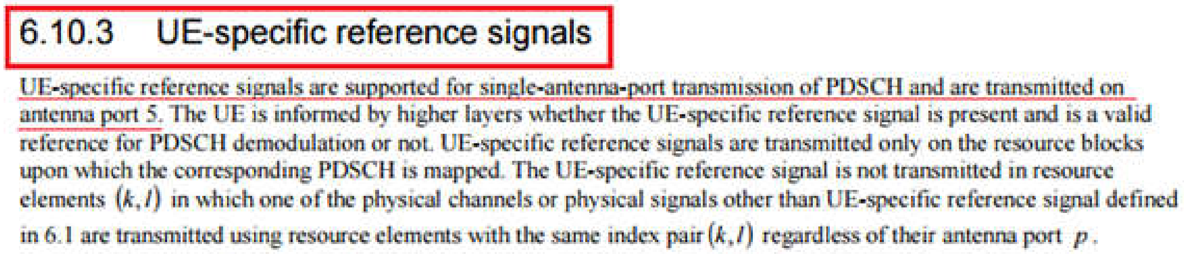
3) Adaptive Beamforming: Adaptive beamforming uses antenna elements with a narrow antenna spacing of about half the carrier wavelength and it has been studied for use with base stations with the antennas mounted in a high location. In this case beamforming is performed by exploiting the UE Direction of Arrival (DoA) or the channel covariance matrix estimated from the uplink, and the resulting transmit weights are not selected from a codebook. In LTE Rel. 8, a UE-specific RS is defined for channel estimation in order to support adaptive beamforming. Unlike the cell-specific RS,

http://blog.3g4g.co.uk/2011/03/quick-recap-of-mimo-in-lte-and-lte.html



The LTE system targets for high data rate, high system capacity and large coverage to provide excellent user experience. Beamforming (BF) is one of the technologies helping to reach this goal, specifically by improving the cell edge performance. LTE as specified in 3GPP Release 8 already supports single-layer beamforming based on user-specific Reference Symbols (also referred to as Dedicated RS or DRS or DM RS). Single-layer beamfroming uses only one codeword, i.e. one transport block. In general the solution allows to direct the beam towards a specific UE through position estimation at the eNodeB (direction of arrival). The eNodeB generates a beam using the array of antenna elements, and then applies the same precoding to both the data payload and the UE-specific reference signal with this beam. It is important to note that the UE-specific reference signal is transmitted in a way such that its time-frequency location does not overlap with the cell-specific reference signal. As the scheme is not involving any UE feedback mechanism, it is specifically suited for LTE in TDD mode of operation, leveraging the reciprocity of the propagation channel in DL and UL direction.

https://cdn.rohde-schwarz.com/pws/dl_downloads/dl_application/application_notes/1ma191/1MA191_0E_LTE_release_9_technology.pdf



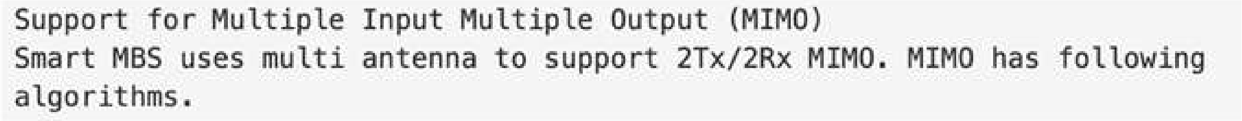
6.10.3 UE-specific reference signals

UE-specific reference signals are supported for single-antenna-port transmission of PDSCH and are transmitted on antenna port 5. The UE is informed by higher layers whether the UE-specific reference signal is present and is a valid reference for PDSCH demodulation or not. UE-specific reference signals are transmitted only on the resource blocks upon which the corresponding PDSCH is mapped. The UE-specific reference signal is not transmitted in resource elements (k,l) in which one of the physical channels or physical signals other than UE-specific reference signal defined in 6.1 are transmitted using resource elements with the same index pair (k,l) regardless of their antenna port p.

http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.08.00_60/ts_136211v080800p.pdf

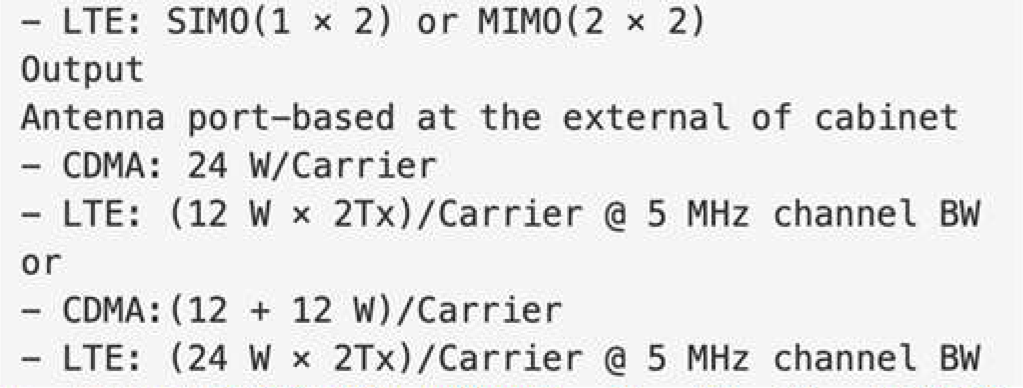
16. The Product comprises a group dividing section (e.g., a processing unit) that divides the plurality of communication terminals (e.g., mobiles, smartphones, tablets, etc.) into a plurality of groups (e.g., dividing mobiles into different sectors within a cell), based on the estimated arrival directions of the receiving signals. The Product divides multiple communication terminals into groups based on the estimated arrival directions of the receiving signals. The base station selects a specific sector antenna to service a particular mobile device if the direction of arrival of a reference signal from said mobile device lies within the direction of arrivals corresponding to a particular sector antenna. In LTE networks, a base station contains multiple antenna (or antenna arrays) to serve users within a cell. A cell can be divided into either 6 sectors or 3 sectors. The accused product divides multiple communication terminals into

groups based on the estimated arrival directions of the receiving signals. The base station selects a specific sector antenna to serve a mobile device, if the direction of arrival of the reference signal from said mobile device lies within the sector served by a particular antenna. For example, if there are three sector antennas (or antenna arrays) to serve a cell, the cell is separated into 120-degree angular coverage areas, so that together they can serve all the users of a particular cell. Similarly, in a situation where six sector antennas (or antenna arrays) are used, antennas (or antenna arrays) are separated into 60-degree angular coverage areas, so that together they can serve all the users of a particular cell. To determine which sector a user device is located within, an LTE base station utilizes the direction of arrival ties to uplink signals sent from a user device. All of the user devices within a particular cell are grouped into a group, N, where N is the number of a sector antenna (antenna array). The determination of a user device's location within a particular section can change based upon that user's movement and thus, grouping of user devices into a particular sector occurs on a dynamic basis. This is illustrated in the publicly available information above and additional information below.



Support for Multiple Input Multiple Output (MIMO)
Smart MBS uses multi antenna to support 2Tx/2Rx MIMO. MIMO has following algorithms.

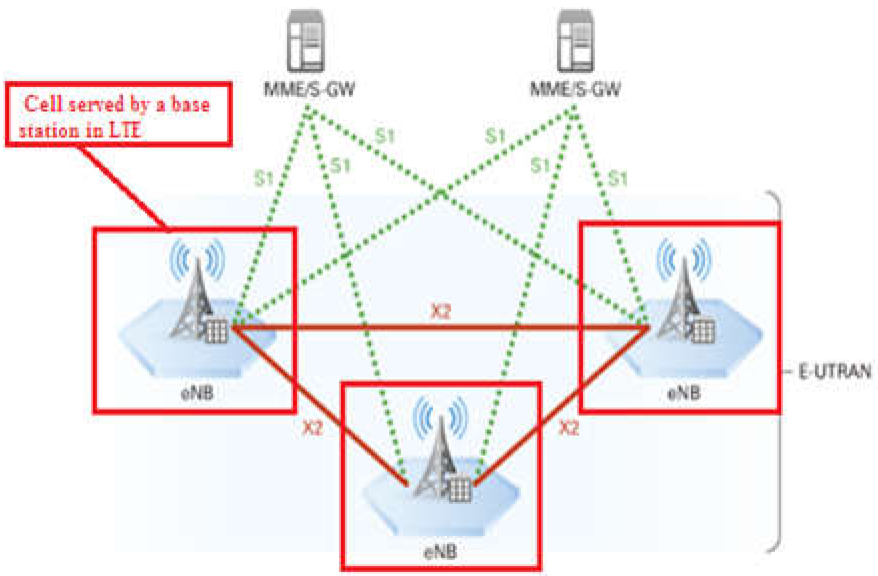
https://fccid.io/A3LSMM-BMAA022000/User-Manual/User-Manual-1688369



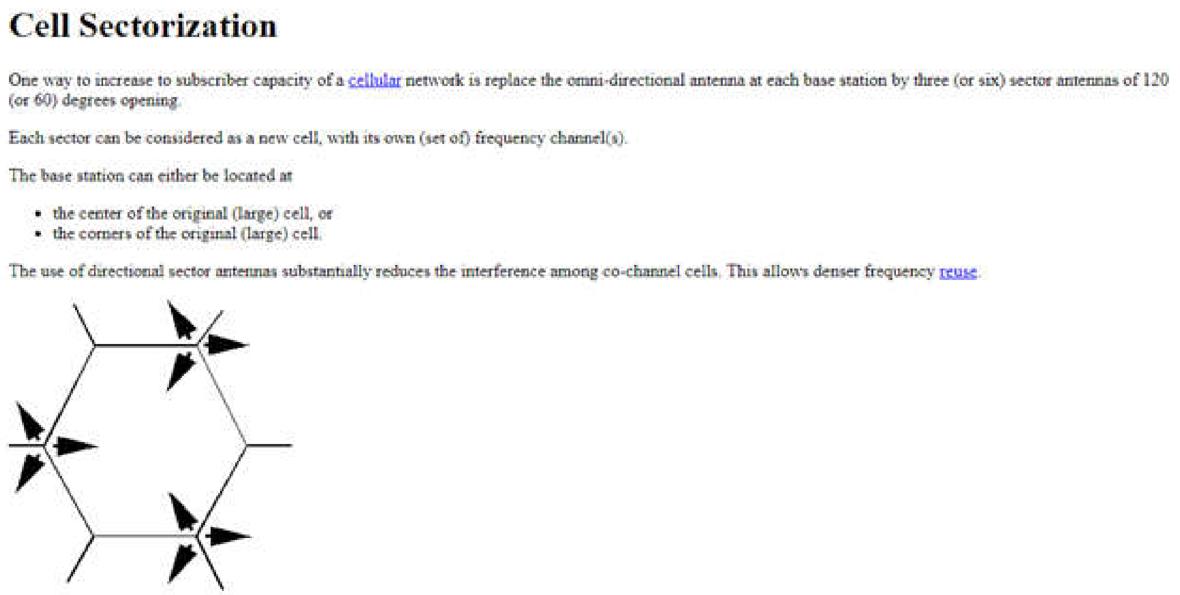
- LTE: SIMO(1 × 2) or MIMO(2 × 2)
Output
Antenna port-based at the external of cabinet
- CDMA: 24 W/Carrier
- LTE: (12 W × 2Tx)/Carrier @ 5 MHz channel BW
or
- CDMA:(12 + 12 W)/Carrier
- LTE: (24 W × 2Tx)/Carrier @ 5 MHz channel BW

https://fccid.io/A3LSMM-BMAA022000/User-Manual/User-Manual-1688369

Figure 2 : E-UTRAN Architecture



http://www.artizanetworks.com/resources/tutorials/what_lteenb.html



Cell Sectorization

One way to increase to subscriber capacity of a cellular network is replace the omni-directional antenna at each base station by three (or six) sector antennas of 120 (or 60) degrees opening.

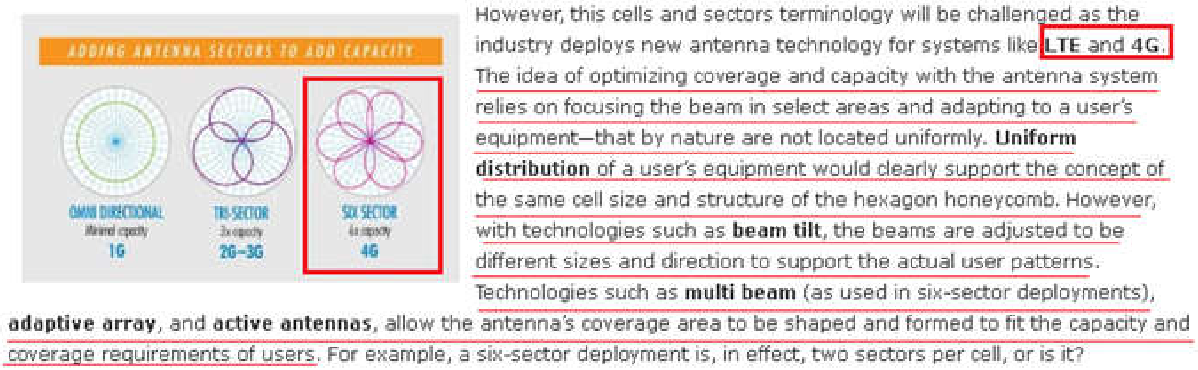
Each sector can be considered as a new cell, with its own (set of) frequency channel(s).

The base station can either be located at

- the center of the original (large) cell, or
- the corners of the original (large) cell.

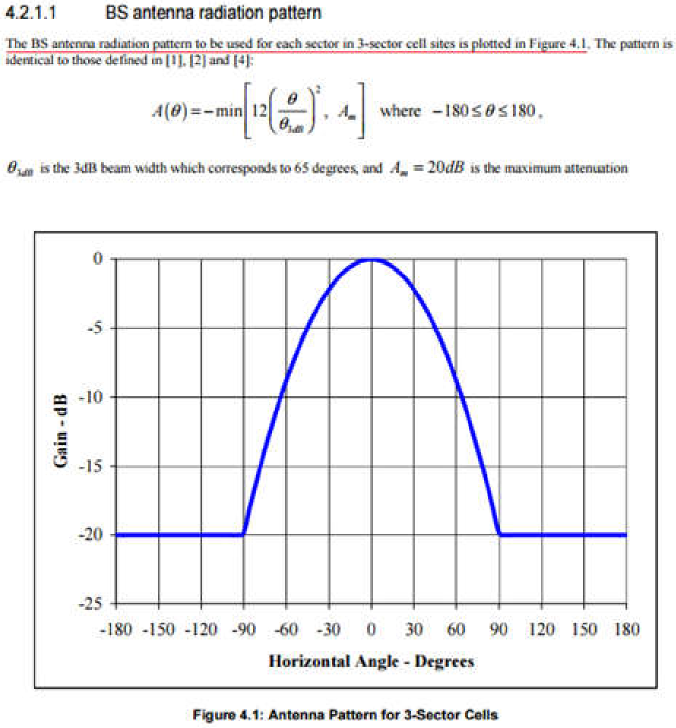
The use of directional sector antennas substantially reduces the interference among co-channel cells. This allows denser frequency reuse.

http://www.wirelesscommunication.nl/reference/chaptr04/cellplan/sector.htm



However, this cells and sectors terminology will be challenged as the industry deploys new antenna technology for systems like LTE and 4G. The idea of optimizing coverage and capacity with the antenna system relies on focusing the beam in select areas and adapting to a user's equipment—that by nature are not located uniformly. **Uniform distribution** of a user's equipment would clearly support the concept of the same cell size and structure of the hexagon honeycomb. However, with technologies such as **beam tilt**, the beams are adjusted to be different sizes and direction to support the actual user patterns. Technologies such as **multi beam** (as used in six-sector deployments), **adaptive array**, and **active antennas**, allow the antenna's coverage area to be shaped and formed to fit the capacity and coverage requirements of users. For example, a six-sector deployment is, in effect, two sectors per cell, or is it?

http://www.commscope.com/Blog/Cells--Sectors-and-Antenna-Beamforming/



4.2.1.1 BS antenna radiation pattern

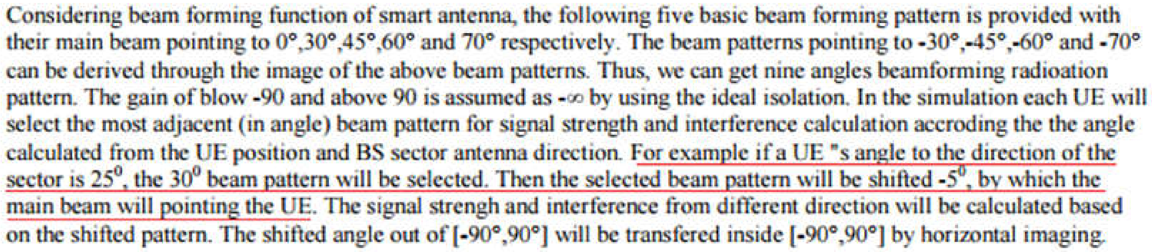
The BS antenna radiation pattern to be used for each sector in 3-sector cell sites is plotted in Figure 4.1. The pattern is identical to those defined in [1], [2] and [4]:

$$A(\theta) = -\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2, A_m\right] \quad \text{where } -180 \le \theta \le 180,$$

θ_{3dB} is the 3dB beam width which corresponds to 65 degrees, and $A_m = 20dB$ is the maximum attenuation

Figure 4.1: Antenna Pattern for 3-Sector Cells

http://www.etsi.org/deliver/etsi_tr/136900_136999/136942/08.02.00_60/tr_136942v080200p.pdf



Considering beam forming function of smart antenna, the following five basic beam forming pattern is provided with their main beam pointing to 0°,30°,45°,60° and 70° respectively. The beam patterns pointing to -30°,-45°,-60° and -70° can be derived through the image of the above beam patterns. Thus, we can get nine angles beamforming radioation pattern. The gain of blow -90 and above 90 is assumed as -∞ by using the ideal isolation. In the simulation each UE will select the most adjacent (in angle) beam pattern for signal strength and interference calculation accroding the the angle calculated from the UE position and BS sector antenna direction. For example if a UE "s angle to the direction of the sector is 25^0, the 30^0 beam pattern will be selected. Then the selected beam pattern will be shifted -5^0, by which the main beam will pointing the UE. The signal strengh and interference from different direction will be calculated based on the shifted pattern. The shifted angle out of [-90°,90°] will be transfered inside [-90°,90°] by horizontal imaging.

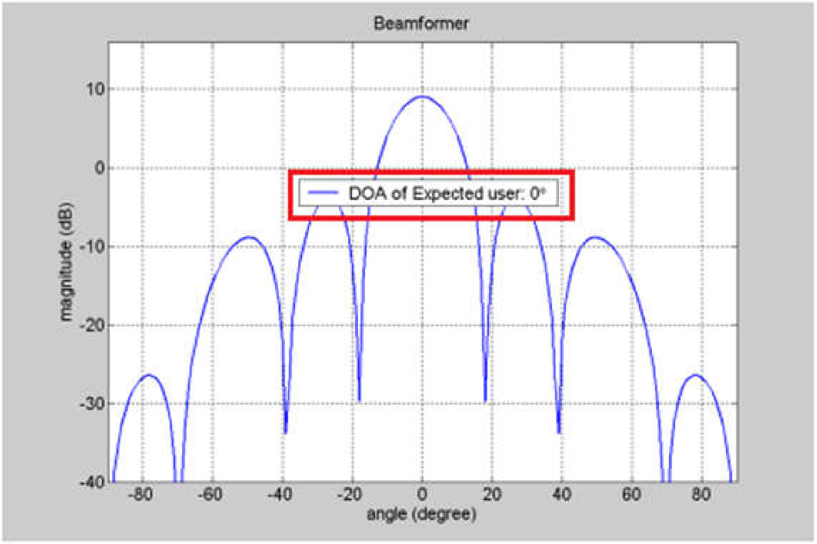


Figure B.1: 0° beam forming pattern

http://www.etsi.org/deliver/etsi_tr/136900_136999/136942/08.04.00_60/tr_136942v080400p.pdf

17. The Product comprises an assignment control section (e.g., a scrambling sequence generator block) that assigns a same scramble code to all communication terminals (e.g., mobiles, smartphones, tablets, etc.) belonging under a same group (e.g., mobiles under a sector of a cell). The scrambling sequence depends upon the initialization value of the scrambling sequence, which in LTE, is calculated based upon the physical layer cell identity. In LTE, a physical layer cell identify is assigned to each sector of a cell. In LTE, each sector is assigned a physical layer cell identity. The scrambling sequence generator then generates a scrambling sequence (scrambling code) based on said physical layer cell identity. Thus, the scrambling code for all the users of a particular sector will be the same because the physical layer cell identity for said sector is the same. The same scramble code is assigned to all communication terminals

belonging under a same group (e.g., the same sector). The equation below shows that the scrambling sequence depends on the value of the physical layer cell identity (NID¬Cell). This is illustrated in the publicly available information above and the additional information below.

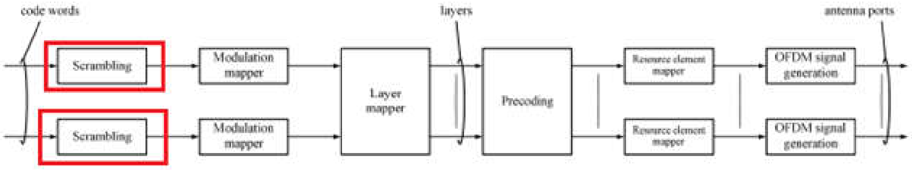
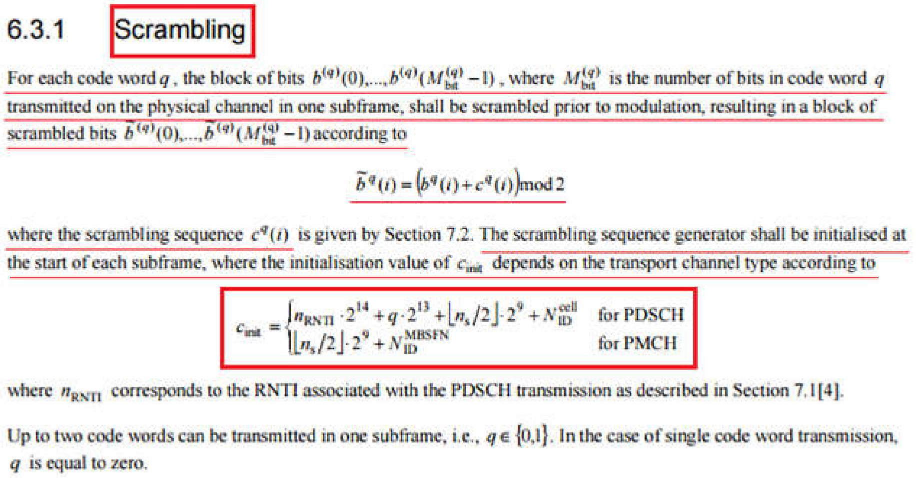


Figure 6.3-1: Overview of physical channel processing.



6.3.1 Scrambling

For each code word q, the block of bits $b^{(q)}(0),...,b^{(q)}(M_{\text{bit}}^{(q)}-1)$, where $M_{\text{bit}}^{(q)}$ is the number of bits in code word q transmitted on the physical channel in one subframe, shall be scrambled prior to modulation, resulting in a block of scrambled bits $\tilde{b}^{(q)}(0),...,\tilde{b}^{(q)}(M_{\text{bit}}^{(q)}-1)$ according to

$$\tilde{b}^{q}(i)=\left(b^{q}(i)+c^{q}(i)\right)\bmod 2$$

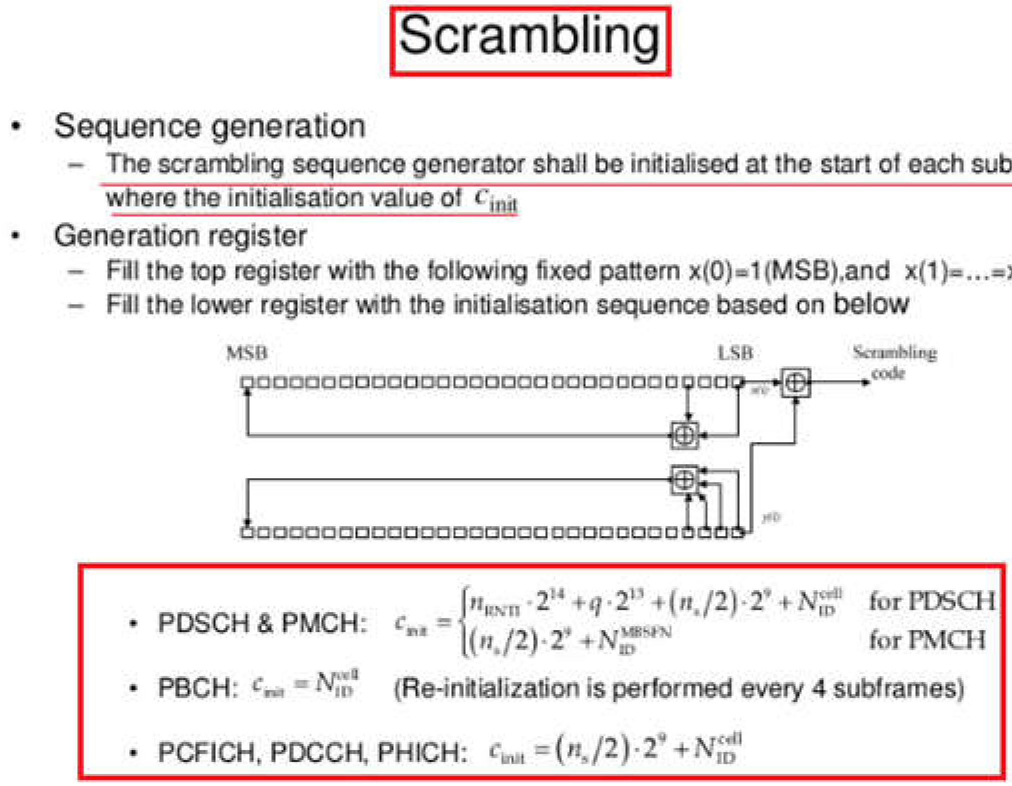
where the scrambling sequence $c^{q}(i)$ is given by Section 7.2. The scrambling sequence generator shall be initialised at the start of each subframe, where the initialisation value of c_{init} depends on the transport channel type according to

$$c_{\text{init}}=\begin{cases} n_{\text{RNTI}}\cdot 2^{14}+q\cdot 2^{13}+\lfloor n_s/2\rfloor\cdot 2^{9}+N_{\text{ID}}^{\text{cell}} & \text{for PDSCH} \\ \lfloor n_s/2\rfloor\cdot 2^{9}+N_{\text{ID}}^{\text{MBSFN}} & \text{for PMCH} \end{cases}$$

where n_{RNTI} corresponds to the RNTI associated with the PDSCH transmission as described in Section 7.1[4].

Up to two code words can be transmitted in one subframe, i.e., $q\in\{0,1\}$. In the case of single code word transmission, q is equal to zero.

http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.08.00_60/ts_136211v080800p.pdf



Scrambling

- Sequence generation
  - The scrambling sequence generator shall be initialised at the start of each subframe, where the initialisation value of c_{init}
- Generation register
  - Fill the top register with the following fixed pattern x(0)=1(MSB),and x(1)=…=x(30)=0.
  - Fill the lower register with the initialisation sequence based on below

- PDSCH & PMCH: $c_{\text{init}} = \begin{cases} n_{\text{RNTI}} \cdot 2^{14} + q \cdot 2^{13} + \lfloor n_s/2 \rfloor \cdot 2^9 + N_{\text{ID}}^{\text{cell}} & \text{for PDSCH} \\ \lfloor n_s/2 \rfloor \cdot 2^9 + N_{\text{ID}}^{\text{MBSFN}} & \text{for PMCH} \end{cases}$
- PBCH: $c_{\text{init}} = N_{\text{ID}}^{\text{cell}}$ (Re-initialization is performed every 4 subframes)
- PCFICH, PDCCH, PHICH: $c_{\text{init}} = \lfloor n_s/2 \rfloor \cdot 2^9 + N_{\text{ID}}^{\text{cell}}$

https://www.slideshare.net/allabout4g/lte-rel-8-physical-layer

6.3 General structure for downlink physical channels

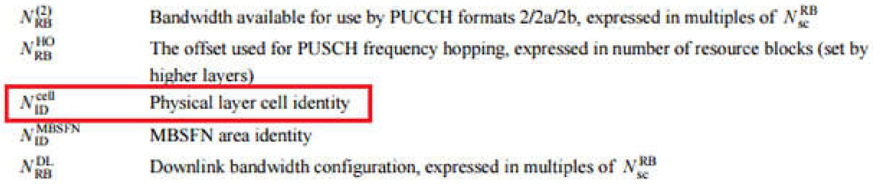
This section describes a general structure, applicable to more than one physical channel.

The baseband signal representing a downlink physical channel is defined in terms of the following steps:

- scrambling of coded bits in each of the code words to be transmitted on a physical channel
- modulation of scrambled bits to generate complex-valued modulation symbols
- mapping of the complex-valued modulation symbols onto one or several transmission layers
- precoding of the complex-valued modulation symbols on each layer for transmission on the antenna ports
- mapping of complex-valued modulation symbols for each antenna port to resource elements
- generation of complex-valued time-domain OFDM signal for each antenna port

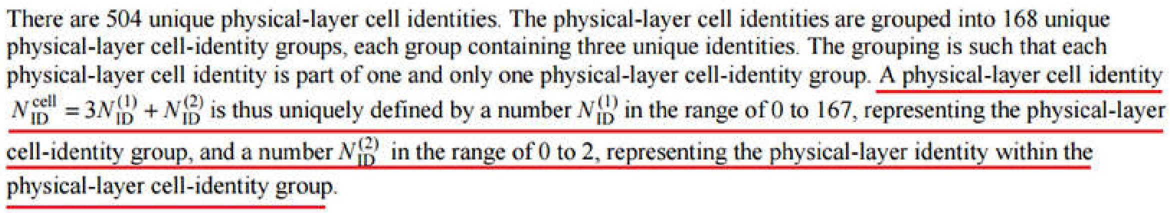
---

http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.08.00_60/ts_136211v080800p.pdf



$N_{RB}^{(2)}$	Bandwidth available for use by PUCCH formats 2/2a/2b, expressed in multiples of N_{sc}^{RB}
N_{RB}^{HO}	The offset used for PUSCH frequency hopping, expressed in number of resource blocks (set by higher layers)
N_{ID}^{cell}	Physical layer cell identity
N_{ID}^{MBSFN}	MBSFN area identity
N_{RB}^{DL}	Downlink bandwidth configuration, expressed in multiples of N_{sc}^{RB}

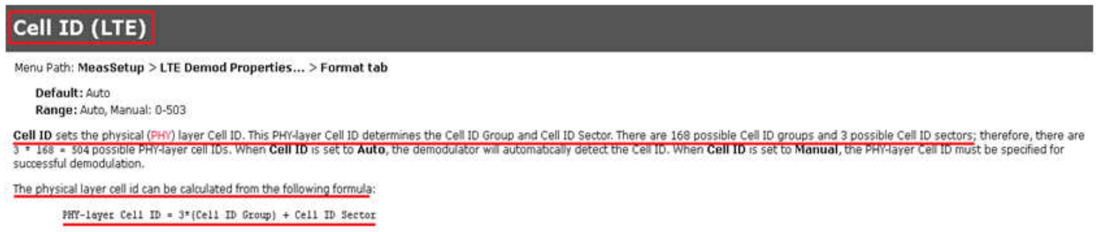
http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.08.00_60/ts_136211v080800p.pdf



There are 504 unique physical-layer cell identities. The physical-layer cell identities are grouped into 168 unique physical-layer cell-identity groups, each group containing three unique identities. The grouping is such that each physical-layer cell identity is part of one and only one physical-layer cell-identity group. A physical-layer cell identity $N_{ID}^{cell} = 3N_{ID}^{(1)} + N_{ID}^{(2)}$ is thus uniquely defined by a number $N_{ID}^{(1)}$ in the range of 0 to 167, representing the physical-layer cell-identity group, and a number $N_{ID}^{(2)}$ in the range of 0 to 2, representing the physical-layer identity within the physical-layer cell-identity group.

http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.09.00_60/ts_136211v080900p.pdf

http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.09.00_60/ts_136211v080900p.pdf



Cell ID (LTE)

Menu Path: **MeasSetup** > **LTE Demod Properties...** > **Format tab**

Default: Auto
Range: Auto, Manual: 0-503

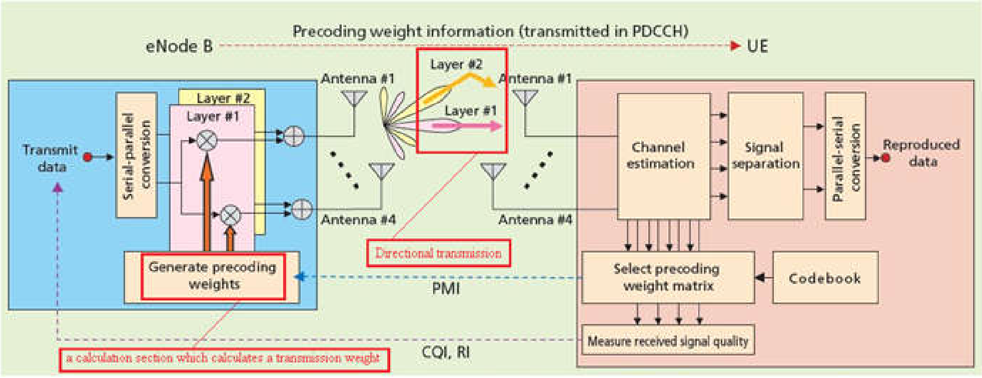
Cell ID sets the physical (PHY) layer Cell ID. This PHY-layer Cell ID determines the Cell ID Group and Cell ID Sector. There are 168 possible Cell ID groups and 3 possible Cell ID sectors; therefore, there are 3 * 168 = 504 possible PHY-layer cell IDs. When **Cell ID** is set to **Auto**, the demodulator will automatically detect the Cell ID. When **Cell ID** is set to **Manual**, the PHY-layer Cell ID must be specified for successful demodulation.

The physical layer cell id can be calculated from the following formula:

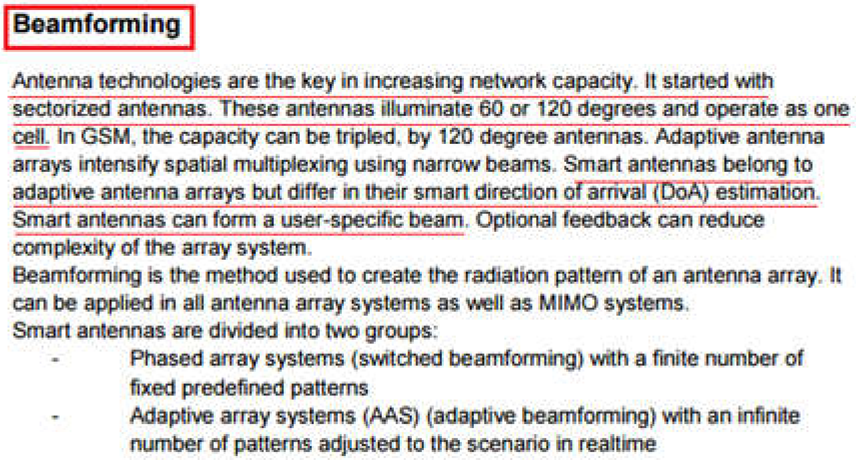
```
PHY-layer Cell ID = 3*(Cell ID Group) + Cell ID Sector
```

http://rfmw.em.keysight.com/wireless/helpfiles/89600b/webhelp/subsystems/lte/content/lte_dlg_fmt_cellid.htm

18. The Product comprises a calculation section (e.g., a precoding weights generating block) that calculates a transmission weight (e.g., a precoding weight) to perform directional transmission (e.g., user equipment specific beamforming) to the plurality of communication terminals (e.g., mobiles, smartphones, tablets, etc.). This is illustrated in the publicly available information above and the additional information below:



http://1.bp.blogspot.com/-ULXNHVGI90w/TZBa9fQZJqI/AAAAAAAADGs/TOiOGGN64lc/s1600/MIMO_NttDocomo_1.jpg



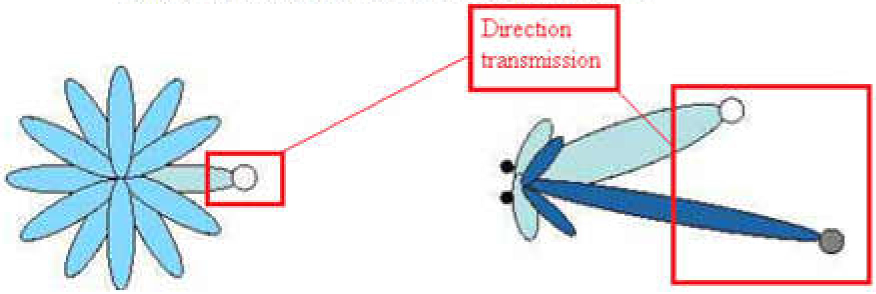
Beamforming

Antenna technologies are the key in increasing network capacity. It started with sectorized antennas. These antennas illuminate 60 or 120 degrees and operate as one cell. In GSM, the capacity can be tripled, by 120 degree antennas. Adaptive antenna arrays intensify spatial multiplexing using narrow beams. Smart antennas belong to adaptive antenna arrays but differ in their smart direction of arrival (DoA) estimation. Smart antennas can form a user-specific beam. Optional feedback can reduce complexity of the array system.

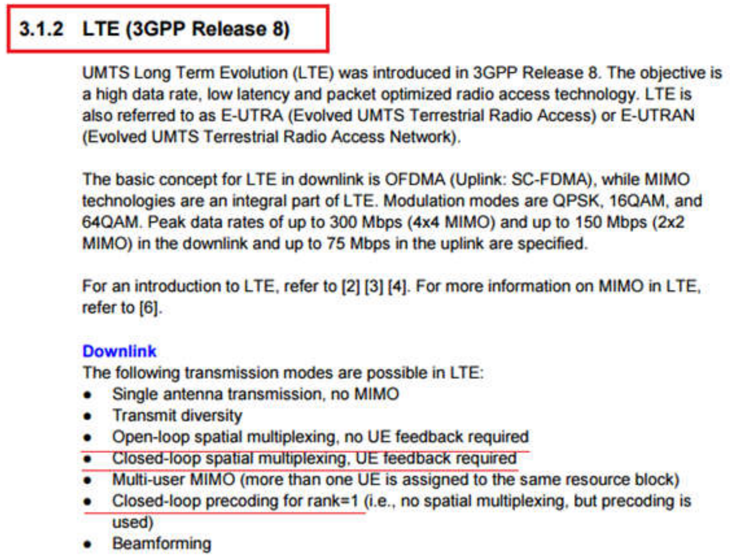
Beamforming is the method used to create the radiation pattern of an antenna array. It can be applied in all antenna array systems as well as MIMO systems.

Smart antennas are divided into two groups:

- Phased array systems (switched beamforming) with a finite number of fixed predefined patterns
- Adaptive array systems (AAS) (adaptive beamforming) with an infinite number of patterns adjusted to the scenario in realtime



https://cdn.rohde-schwarz.com/pws/dl_downloads/dl_application/application_notes/1ma142/1MA142_0e_introduction_to_MIMO.pdf



3.1.2 LTE (3GPP Release 8)

UMTS Long Term Evolution (LTE) was introduced in 3GPP Release 8. The objective is a high data rate, low latency and packet optimized radio access technology. LTE is also referred to as E-UTRA (Evolved UMTS Terrestrial Radio Access) or E-UTRAN (Evolved UMTS Terrestrial Radio Access Network).

The basic concept for LTE in downlink is OFDMA (Uplink: SC-FDMA), while MIMO technologies are an integral part of LTE. Modulation modes are QPSK, 16QAM, and 64QAM. Peak data rates of up to 300 Mbps (4x4 MIMO) and up to 150 Mbps (2x2 MIMO) in the downlink and up to 75 Mbps in the uplink are specified.

For an introduction to LTE, refer to [2] [3] [4]. For more information on MIMO in LTE, refer to [6].

Downlink

The following transmission modes are possible in LTE:

- Single antenna transmission, no MIMO
- Transmit diversity
- Open-loop spatial multiplexing, no UE feedback required
- Closed-loop spatial multiplexing, UE feedback required
- Multi-user MIMO (more than one UE is assigned to the same resource block)
- Closed-loop precoding for rank=1 (i.e., no spatial multiplexing, but precoding is used)
- Beamforming

https://cdn.rohde-schwarz.com/pws/dl_downloads/dl_application/application_notes/1ma142/1MA142_0e_introduction_to_MIMO.pdf

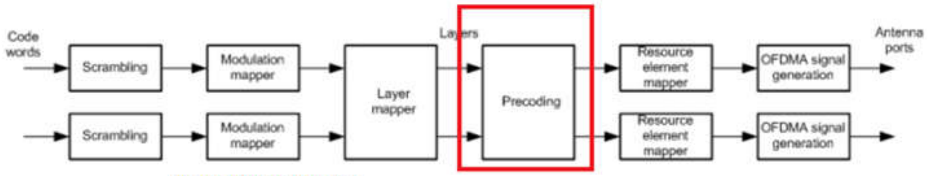
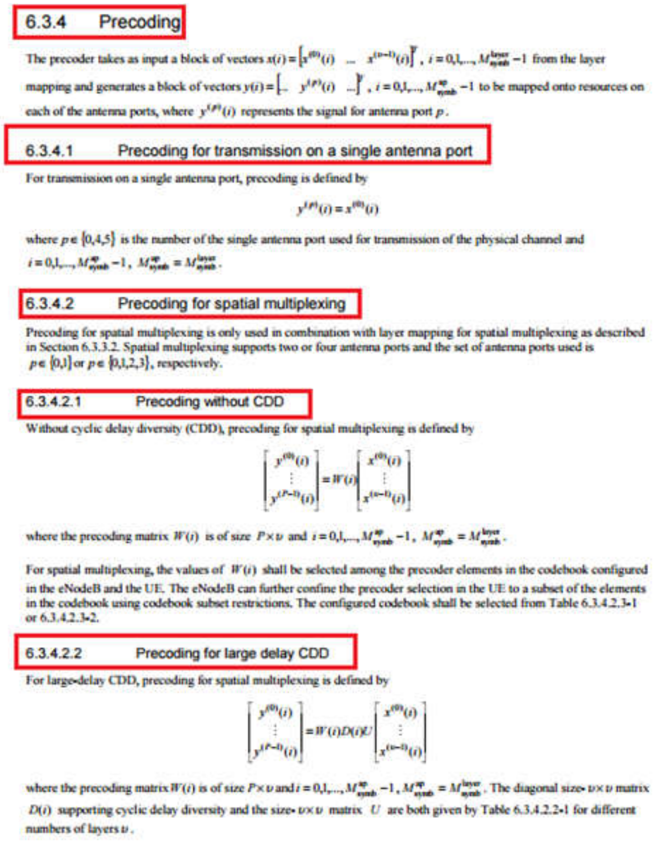


Figure 12: LTE downlink

https://cdn.rohde-schwarz.com/pws/dl_downloads/dl_application/application_notes/1ma142/1MA142_0e_introduction_to_MIMO.pdf



6.3.4 Precoding

The precoder takes as input a block of vectors $x(i) = \left[x^{(0)}(i) \ \ldots \ x^{(\upsilon-1)}(i)\right]^T$, $i = 0,1,\ldots,M_{\text{symb}}^{\text{layer}} - 1$ from the layer mapping and generates a block of vectors $y(i) = \left[\ldots \ y^{(p)}(i) \ \ldots\right]^T$, $i = 0,1,\ldots,M_{\text{symb}}^{\text{ap}} - 1$ to be mapped onto resources on each of the antenna ports, where $y^{(p)}(i)$ represents the signal for antenna port p.

6.3.4.1 Precoding for transmission on a single antenna port

For transmission on a single antenna port, precoding is defined by

$$y^{(p)}(i) = x^{(0)}(i)$$

where $p \in \{0,4,5\}$ is the number of the single antenna port used for transmission of the physical channel and $i = 0,1,\ldots,M_{\text{symb}}^{\text{ap}} - 1$, $M_{\text{symb}}^{\text{ap}} = M_{\text{symb}}^{\text{layer}}$.

6.3.4.2 Precoding for spatial multiplexing

Precoding for spatial multiplexing is only used in combination with layer mapping for spatial multiplexing as described in Section 6.3.3.2. Spatial multiplexing supports two or four antenna ports and the set of antenna ports used is $p \in \{0,1\}$ or $p \in \{0,1,2,3\}$, respectively.

6.3.4.2.1 Precoding without CDD

Without cyclic delay diversity (CDD), precoding for spatial multiplexing is defined by

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(\upsilon-1)}(i) \end{bmatrix}$$

where the precoding matrix $W(i)$ is of size $P \times \upsilon$ and $i = 0,1,\ldots,M_{\text{symb}}^{\text{ap}} - 1$, $M_{\text{symb}}^{\text{ap}} = M_{\text{symb}}^{\text{layer}}$.

For spatial multiplexing, the values of $W(i)$ shall be selected among the precoder elements in the codebook configured in the eNodeB and the UE. The eNodeB can further confine the precoder selection in the UE to a subset of the elements in the codebook using codebook subset restrictions. The configured codebook shall be selected from Table 6.3.4.2.3-1 or 6.3.4.2.3-2.

6.3.4.2.2 Precoding for large delay CDD

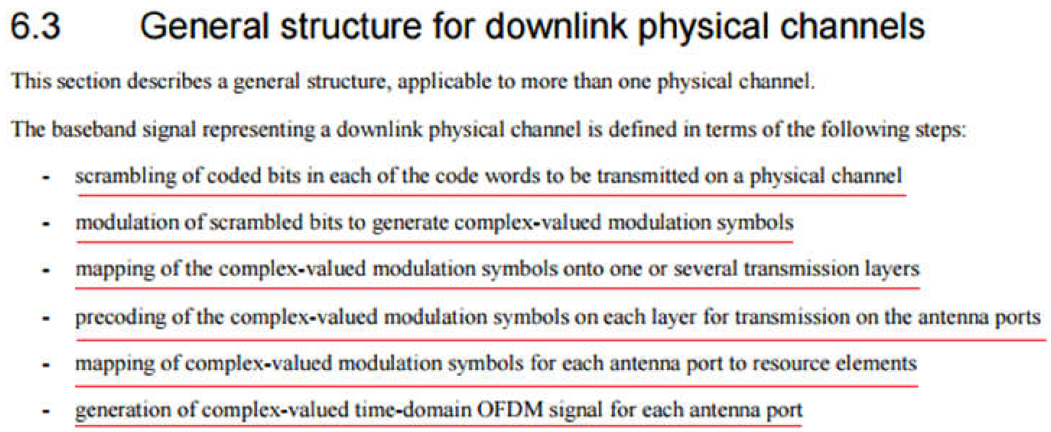
For large-delay CDD, precoding for spatial multiplexing is defined by

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i)D(i)U \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(\upsilon-1)}(i) \end{bmatrix}$$

where the precoding matrix $W(i)$ is of size $P \times \upsilon$ and $i = 0,1,\ldots,M_{\text{symb}}^{\text{ap}} - 1$, $M_{\text{symb}}^{\text{ap}} = M_{\text{symb}}^{\text{layer}}$. The diagonal size-$\upsilon \times \upsilon$ matrix $D(i)$ supporting cyclic delay diversity and the size-$\upsilon \times \upsilon$ matrix U are both given by Table 6.3.4.2.2-1 for different numbers of layers υ.

http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.08.00_60/ts_136211v080800p.pdf

19. The Product comprises a directional transmission section (e.g., antenna section) that directionally transmits (e.g., user specific beamforming) a transmission signal modulated with the assigned scramble code (e.g., an OFDM signal), using the calculated transmission weight (e.g., determined precoding weight). The Product modulates the scrambled transmission signals (e.g., code words) and also comprises a directional transmission section (e.g., antenna section) which directionally transmits (e.g., a user specific beamforming) the modulated signal to the plurality of communication terminals (e.g., mobiles, smartphones, tablets, etc.) using the calculated transmission weight (e.g., determined precoding weight). This is illustrated in the publicly available information above and the additional information below.



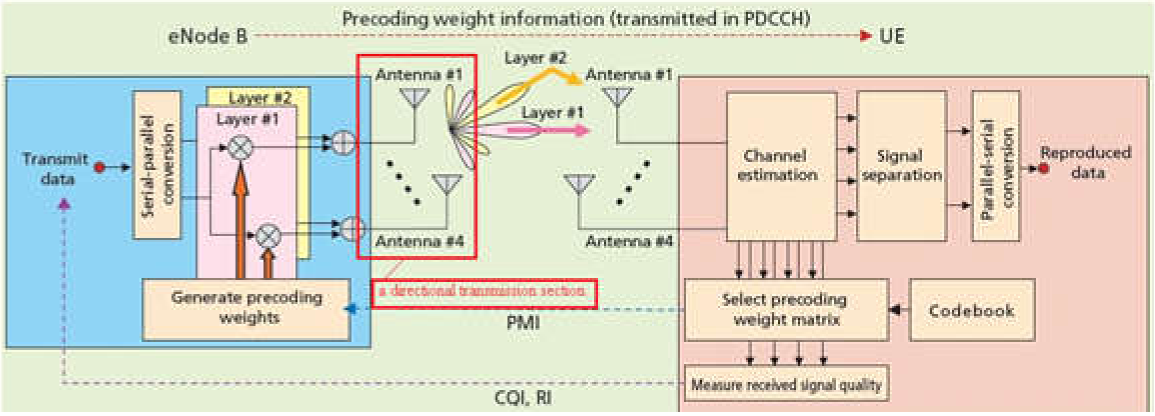
6.3 General structure for downlink physical channels

This section describes a general structure, applicable to more than one physical channel.

The baseband signal representing a downlink physical channel is defined in terms of the following steps:

- scrambling of coded bits in each of the code words to be transmitted on a physical channel
- modulation of scrambled bits to generate complex-valued modulation symbols
- mapping of the complex-valued modulation symbols onto one or several transmission layers
- precoding of the complex-valued modulation symbols on each layer for transmission on the antenna ports
- mapping of complex-valued modulation symbols for each antenna port to resource elements
- generation of complex-valued time-domain OFDM signal for each antenna port

http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.08.00_60/ts_136211v080800p.pdf



http://1.bp.blogspot.com/-ULXNHVGI90w/TZBa9fQZJqI/AAAAAAAADGs/TOiOGGN64lc/s1600/MIMO_NttDocomo_1.jpg

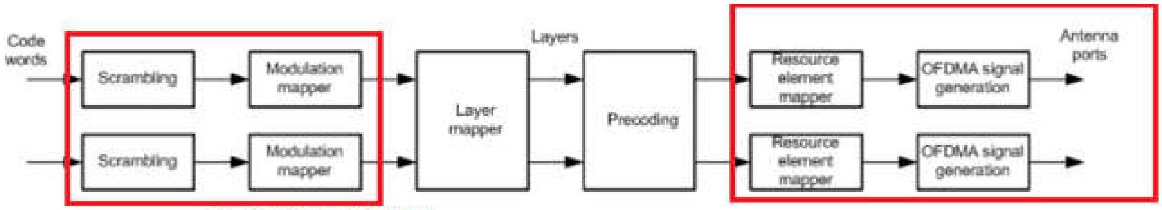
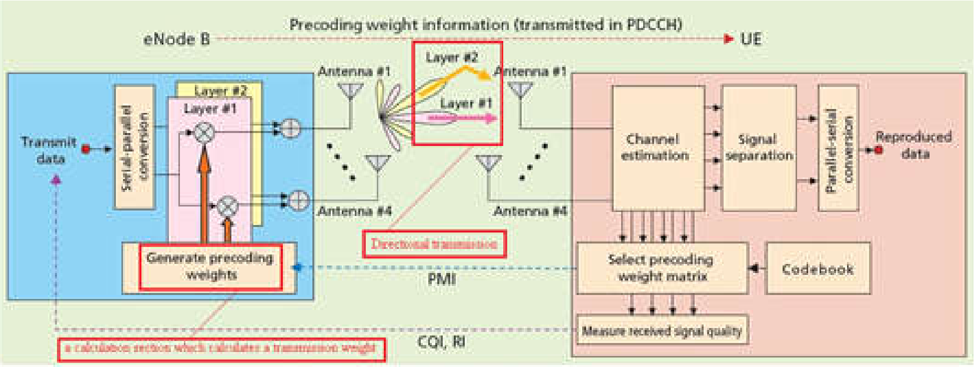


Figure 12: LTE downlink

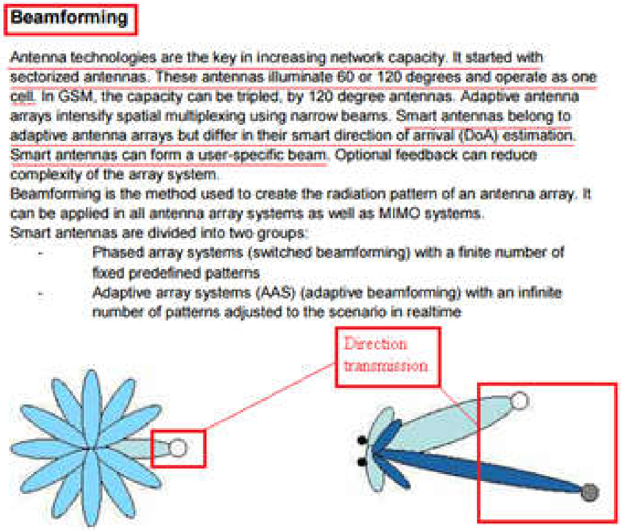
https://cdn.rohde-schwarz.com/pws/dl_downloads/dl_application/application_notes/1ma142/1MA142_0e_introduction_to_MIMO.pdf

20. The Product comprises a calculation section (e.g., a precoding calculation section) calculates the transmission weight (e.g., a precode) that is common to all the communication terminals (e.g., mobiles, smartphones, tablets, etc.) belonging under the same group (e.g.,

mobiles under a sector of a cell). Shown below is the beam pattern of a 6-sector cell in LTE. Each sector has one beam associated therewith. Because transmission weights/precoding weights are calculated for forming beams and each sector has one beam associated therewith, the transmission weight will be common for all the communication terminals within a sector. This is illustrated in the publicly available information above and the additional information below.



http://1.bp.blogspot.com/-ULXNHVGI90w/TZBa9fQZJqI/AAAAAAAADGs/TOiOGGN64lc/s1600/MIMO_NttDocomo_1.jpg

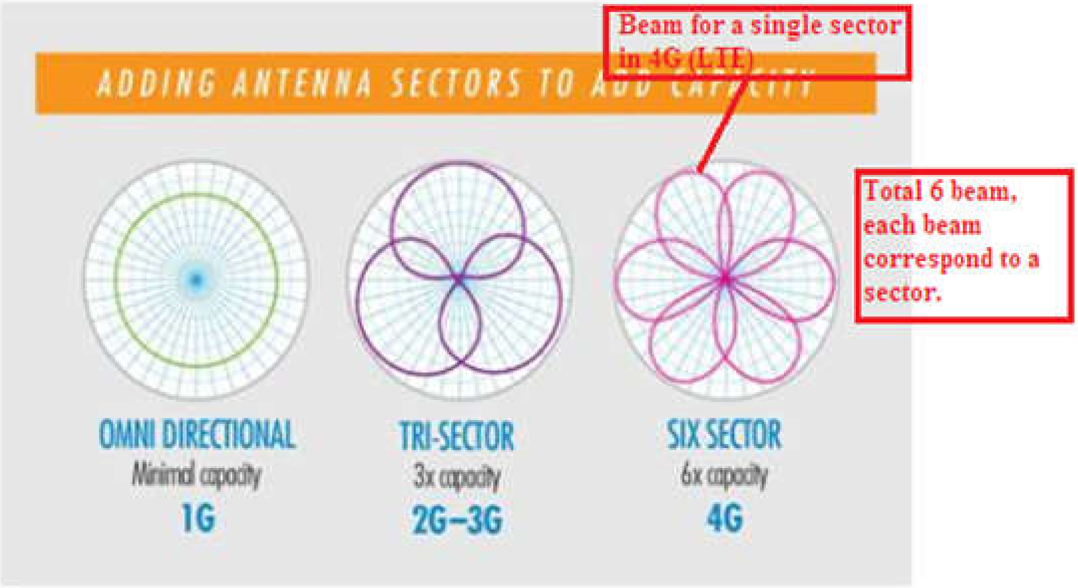


Beamforming

Antenna technologies are the key in increasing network capacity. It started with sectorized antennas. These antennas illuminate 60 or 120 degrees and operate as one cell. In GSM, the capacity can be tripled, by 120 degree antennas. Adaptive antenna arrays intensify spatial multiplexing using narrow beams. Smart antennas belong to adaptive antenna arrays but differ in their smart direction of arrival (DoA) estimation. Smart antennas can form a user-specific beam. Optional feedback can reduce complexity of the array system.
Beamforming is the method used to create the radiation pattern of an antenna array. It can be applied in all antenna array systems as well as MIMO systems.
Smart antennas are divided into two groups:

- Phased array systems (switched beamforming) with a finite number of fixed predefined patterns
- Adaptive array systems (AAS) (adaptive beamforming) with an infinite number of patterns adjusted to the scenario in realtime

https://cdn.rohde-schwarz.com/pws/dl_downloads/dl_application/application_notes/1ma142/1MA142_0e_introduction_to_MIMO.pdf



Beam for a single sector in 4G (LTE)

Total 6 beam, each beam correspond to a sector.

https://www.commscope.com/Blog/Cells--Sectors-and-Antenna-Beamforming/

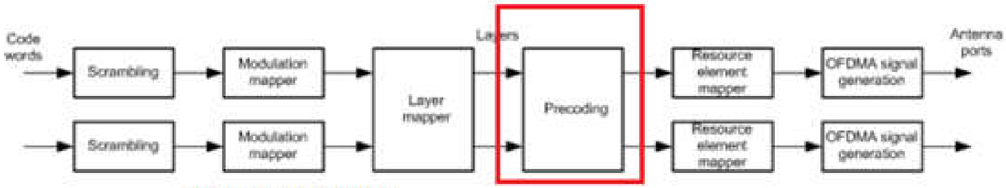
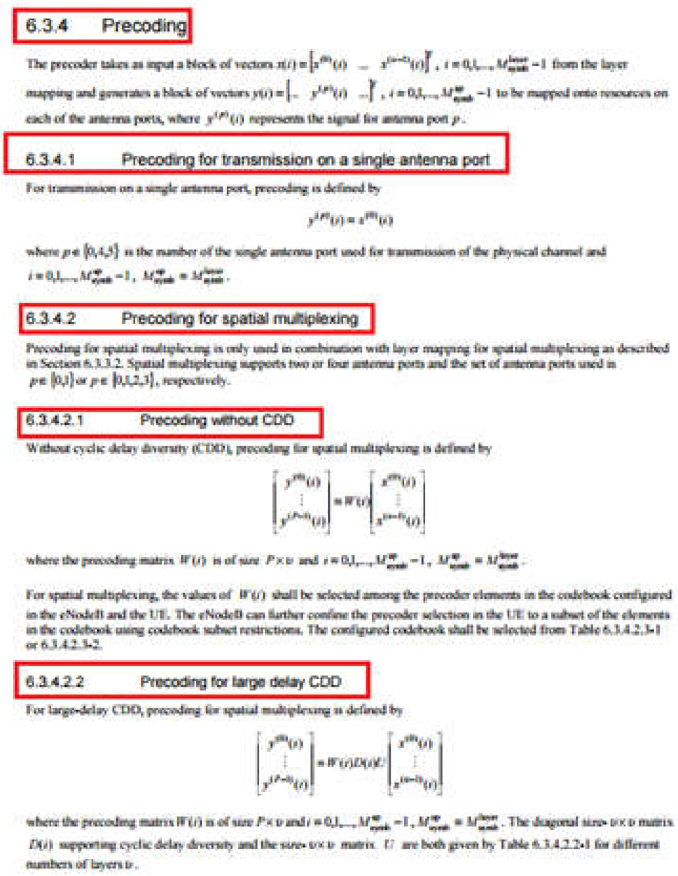


Figure 12: LTE downlink

https://cdn.rohde-schwarz.com/pws/dl_downloads/dl_application/application_notes/1ma142/1MA142_0e_introduction_to_MIMO.pdf



6.3.4 Precoding

The precoder takes as input a block of vectors $x(i)=\left[x^{(0)}(i)\ \ldots\ x^{(\upsilon-1)}(i)\right]^T$, $i=0,1,\ldots,M_{\mathrm{symb}}^{\mathrm{layer}}-1$ from the layer mapping and generates a block of vectors $y(i)=\left[\ldots\ y^{(p)}(i)\ \ldots\right]^T$, $i=0,1,\ldots,M_{\mathrm{symb}}^{\mathrm{ap}}-1$ to be mapped onto resources on each of the antenna ports, where $y^{(p)}(i)$ represents the signal for antenna port p.

6.3.4.1 Precoding for transmission on a single antenna port

For transmission on a single antenna port, precoding is defined by

$$y^{(p)}(i)=x^{(0)}(i)$$

where $p\in\{0,4,5\}$ is the number of the single antenna port used for transmission of the physical channel and $i=0,1,\ldots,M_{\mathrm{symb}}^{\mathrm{ap}}-1$, $M_{\mathrm{symb}}^{\mathrm{ap}}=M_{\mathrm{symb}}^{\mathrm{layer}}$.

6.3.4.2 Precoding for spatial multiplexing

Precoding for spatial multiplexing is only used in combination with layer mapping for spatial multiplexing as described in Section 6.3.3.2. Spatial multiplexing supports two or four antenna ports and the set of antenna ports used is $p\in\{0,1\}$ or $p\in\{0,1,2,3\}$, respectively.

6.3.4.2.1 Precoding without CDD

Without cyclic delay diversity (CDD), precoding for spatial multiplexing is defined by

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i) \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(\upsilon-1)}(i) \end{bmatrix}$$

where the precoding matrix $W(i)$ is of size $P\times\upsilon$ and $i=0,1,\ldots,M_{\mathrm{symb}}^{\mathrm{ap}}-1$, $M_{\mathrm{symb}}^{\mathrm{ap}}=M_{\mathrm{symb}}^{\mathrm{layer}}$.

For spatial multiplexing, the values of $W(i)$ shall be selected among the precoder elements in the codebook configured in the eNodeB and the UE. The eNodeB can further confine the precoder selection in the UE to a subset of the elements in the codebook using codebook subset restrictions. The configured codebook shall be selected from Table 6.3.4.2.3-1 or 6.3.4.2.3-2.

6.3.4.2.2 Precoding for large delay CDD

For large-delay CDD, precoding for spatial multiplexing is defined by

$$\begin{bmatrix} y^{(0)}(i) \\ \vdots \\ y^{(P-1)}(i) \end{bmatrix} = W(i)D(i)U \begin{bmatrix} x^{(0)}(i) \\ \vdots \\ x^{(\upsilon-1)}(i) \end{bmatrix}$$

where the precoding matrix $W(i)$ is of size $P\times\upsilon$ and $i=0,1,\ldots,M_{\mathrm{symb}}^{\mathrm{ap}}-1$, $M_{\mathrm{symb}}^{\mathrm{ap}}=M_{\mathrm{symb}}^{\mathrm{layer}}$. The diagonal size-$\upsilon\times\upsilon$ matrix $D(i)$ supporting cyclic delay diversity and the size-$\upsilon\times\upsilon$ matrix U are both given by Table 6.3.4.2.2-1 for different numbers of layers υ.

http://www.etsi.org/deliver/etsi_ts/136200_136299/136211/08.08.00_60/ts_136211v080800p.pdf

21. The Product comprises a directional transmission section (e.g., antenna section) that performs transmission with a same directivity (e.g., user-specific beamforming) to all the communication terminals (e.g., mobiles, smartphones, tablets, etc.) belonging under the same group (e.g., mobiles under a sector of a cell). Because all communication terminals (e.g. user devices) within a single sector of a cell are served by the same antennae beam, all transmissions to said communications terminals must share the same directivity. These elements are illustrated in the screen shots provided in connection with other allegations herein.

22. Regarding Claim 9, the Product The accused product (e.g., LTE base station) practices a radio communication (e.g., cellular communication) method. The Product practices estimating arrival directions of receiving signals (e.g., direction of received uplink signal) from a

plurality of communication terminals (e.g., mobiles, smartphones, tablets, etc.). The base station estimates direction of arrival of receiving signal from a user equipment for optimum beamforming. The Product practices dividing the plurality of communication terminals into a plurality of groups (e.g., dividing mobiles into different sectors within a cell), based on the estimated arrival directions of the receiving signals. The base station selects a specific sector antenna for a mobile, if the direction of arrival of reference signal from the mobile lies in the sector of that antenna. The Product practices assigning a same scramble code to all communication terminals belonging under a same group (e.g., mobiles under a sector of a cell). Upon information and belief, the accused product practices assigning, by an assignment control section (e.g., a scrambling sequence generator block), which assigns a same scramble code to all communication terminals belonging under a same group. The scrambling sequence depends upon the initialization value of the scrambling sequence, which is calculated on basis of the physical layer cell identity of the base station. The physical layer cell identity determines cell ID group and cell ID sector. The accused product practices calculating a transmission weight (e.g., a precoding weight) to perform directional transmission (e.g., user equipment specific beamforming) to the plurality of communication terminals (e.g., mobiles, smartphones, tablets, etc.). The Product practices directionally transmitting (e.g., user specific beamforming) a transmission signal modulated with the assigned scramble code (e.g., an OFDM signal), using the calculated transmission weight (e.g., determined precode). The Product modulates the scrambled transmission signals (e.g., code words) and also comprises a directional transmission section (e.g., antenna section) which directionally transmits (e.g., a user specific beamforming) the modulated signal to the plurality of communication terminals (e.g., mobiles, smartphones, tablets) using the calculated transmission weight (e.g., determined precode). The Product practices, in the transmission weight calculation step, the calculated transmission weight (e.g., a precode) that is common to all the communication terminals belonging under the same group. The Product practices in the directional transmission step, transmission is performed with a same directivity (e.g., user-specific beamforming) to all the communication terminals belonging under the same group. These elements are further illustrated in the allegations above in connection with Claim 1.

23. Defendant's actions complained of herein will continue unless Defendant is enjoined by this court.

24. Defendant's actions complained of herein are causing irreparable harm and monetary damage to Plaintiff and will continue to do so unless and until Defendant is enjoined and restrained by this Court.

25. Plaintiff is in compliance with 35 U.S.C. § 287.

JURY DEMAND

Plaintiff, under Rule 38 of the Federal Rules of Civil Procedure, requests a trial by jury of any issues so triable by right.

PRAYER FOR RELIEF

WHEREFORE, Plaintiff asks the Court to:

(a) Enter judgment for Plaintiff on this Complaint on all causes of action asserted herein;

(b) Enter an Order enjoining Defendant, its agents, officers, servants, employees, attorneys, and all persons in active concert or participation with Defendant who receive notice of the order from further infringement of United States Patent No. 6,684,086 (or, in the alternative, awarding Plaintiff a running royalty from the time of judgment going forward);

(c) Award Plaintiff damages resulting from Defendant's infringement in accordance with 35 U.S.C. § 284;

(d) Award Plaintiff pre-judgment and post-judgment interest and costs; and

(e) Award Plaintiff such further relief to which the Court finds Plaintiff entitled under law or equity.

Dated: January 31, 2019

Respectfully submitted,

/s/ Jay Johnson
JAY JOHNSON
State Bar No. 24067322
D. BRADLEY KIZZIA
State Bar No. 11547550
KIZZIA JOHNSON, PLLC
1910 Pacific Ave., Suite 13000
Dallas, Texas 75201
(214) 451-0164
Fax: (214) 451-0165
jay@kjpllc.com
bkizzia@kjpllc.com

ATTORNEYS FOR PLAINTIFF

EXHIBIT A