สำนักงานคณะกรรมการกิจการกระจายเสียง
กิจการโทรทัศน์และกิจการโทรคมนาคมแห่งชาติ (กสทช.)
Office of the National Broadcasting and
Telecommunications Commission (NBTC)

โทรทัศน์ดิจิตอลระบบ DVB-T2 : เทคโนโลยีและมาตรฐานทางเทคนิค

(DVB-T2 System: Technology and Technical Standards)

สุภัทรสิทธิ์ สวนสุข
วิศวกร กลุ่มงานมาตรฐานและเทคโนโลยีกระจายเสียงและโทรทัศน์ สำนักงาน กสทช.
เลขานุการคณะทำงานจัดทำแผนความถี่วิทยุและมาตรฐานทางเทคนิคสำหรับกิจการโทรทัศน์
ธันวาคม 2555

Content

NBTC

- History of Television Technology in Thailand
- Introduction to DVB
- Basic of DVB-T2
- Key Features of DVB-T2
- DVB-T2 Planning
- NBTC Notifications on DTTB Technical Standards and Frequency Plan

History of Television Technology in Thailand

12 yrs.

46 yrs.

B.E.2498 (1955)
First Black/White Television Transmission in Thailand

"Channel 4 Bangkhunphrom"

FCC 525 Lines (Black/White)

B.E.2510 (1967)
Color Television Broadcast Station (Analog Station)

CCIR PAL 625 Lines

B.E.2556 (2013)
Digital Television Broadcast Station

Royal Thai Army (Ch.5) starts trial transmission from Baiyok II Tower on January 25, 2013

DVB-T2

History of Television Technology in Thailand (National Frequency Plan)

NBTC Frequency Plan for Digital Terrestrial Television Broadcasting B.E.2555 (2012)

Frequency Plan for VHF/UHF Analog Television B.E.2539 (1996)

Frequency Plan for UHF Analog Television B.E.2530 (1987)

Frequency Plan for VHF Analog Television B.E.2528 (1985)

Broadcasting Service Master Plan (2012 – 2016)

- Strategy 5.6 of the master plan : *"Transition to Digital Television and Digital Radio"*
  - Shall begin the digital terrestrial television broadcasting within 4 years
  - 80% of Households in major cities shall be able to receive digital radio and digital television services within 5 years

Introduction to DVB

Second Generation of DVB Systems

NBTC

DVB S2®

At least 30% more capacity

3 dB more robust

Millions of receivers deployed

DVB T2®

At least 50% more capacity

6 dB more robust

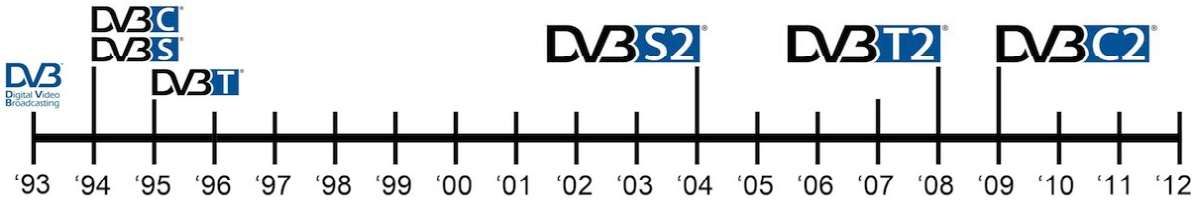
Millions of receivers deployed

DVB C2®

At least 50% more capacity

6 dB more robust

Receivers now available



Second Generation of DVB Systems

NBTC

- Driver for 2nd generation
  - Additional capacity for HD and 3D
  - Improved chip set technology
  - New algorithms
  - New business models
- Features of 2nd generation
  - Close to theoretical limits
  - Capacity and/or robustness increase
  - Support of new delivery schemes

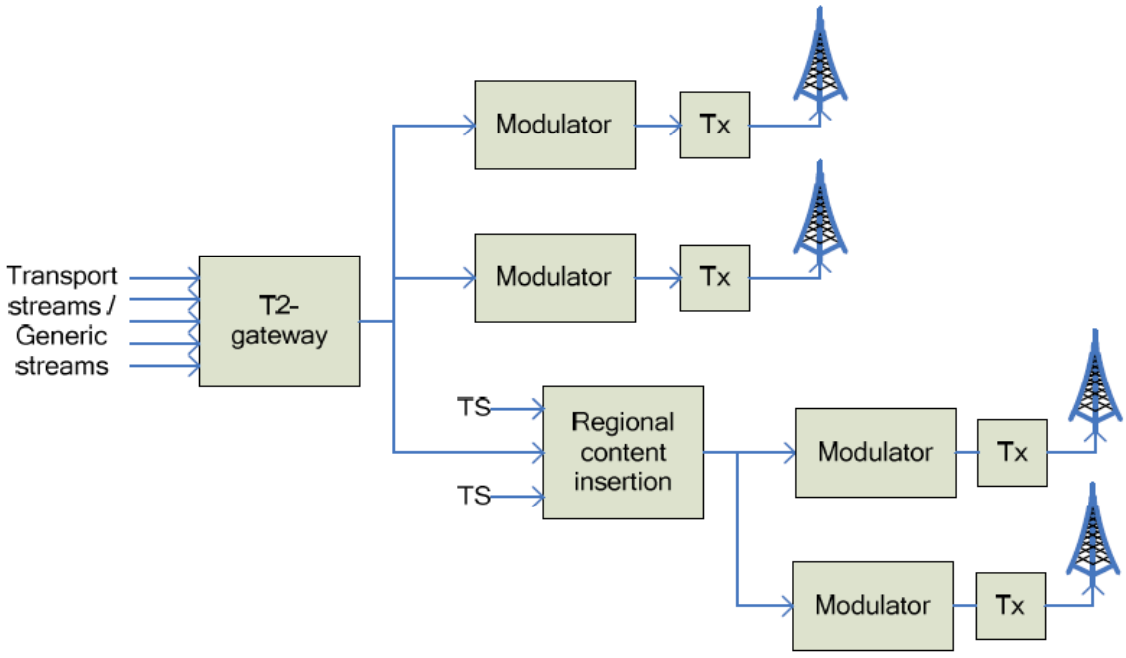
DVB S2®

DVB T2®

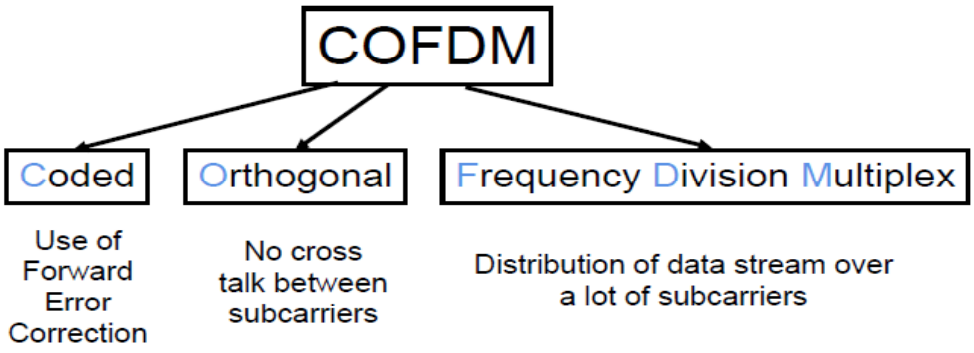
DVB C2®

Basic of DVB-T2

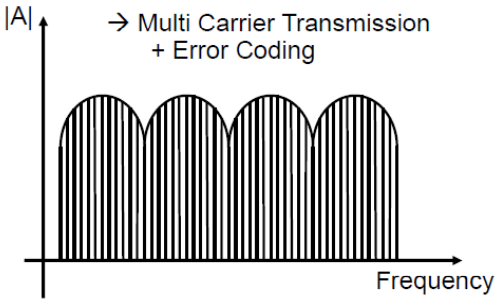
Basic DVB-T2 Transmission Systems



Fundamental Technology of DVB-T2

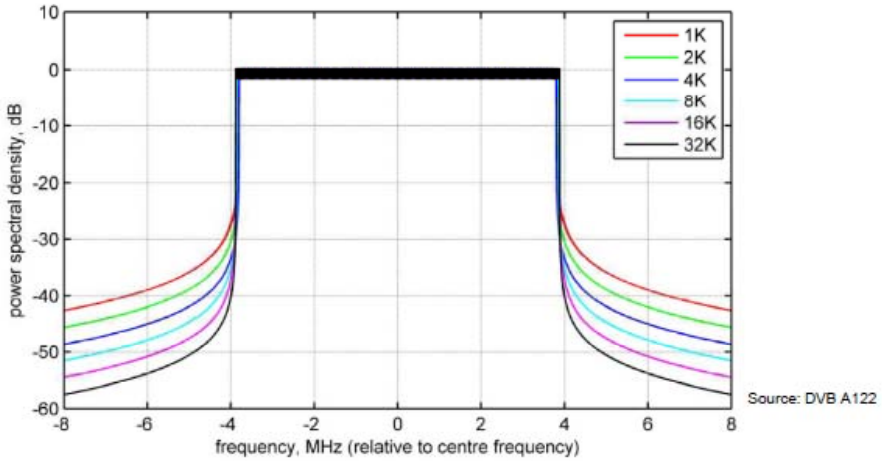


	FEC
Inner	LDPC (Low Density Parity Check)
Outer	BCH (Bose-Chaudhuri-Hocquenghem)



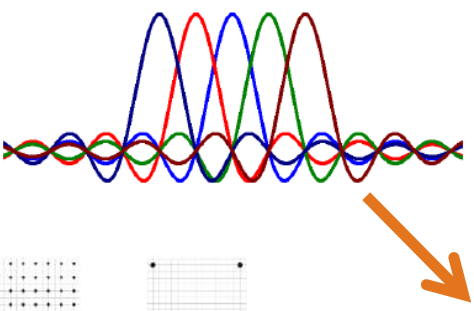
FFT size
32K
16K
8K
4K
2K
1K

Number of carriers



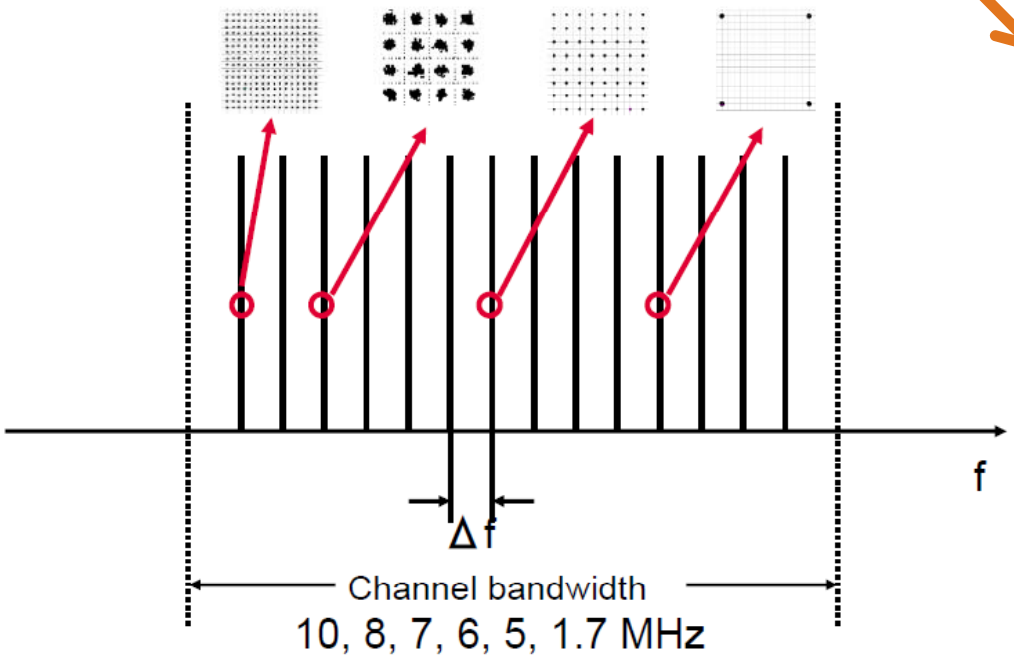
Parameter	1K	2K	4K	8K	16K	32K
Number of carriers (Extended Mode)	853	1705	3409	6817 (6912)	13633 (13920)	27265 (27840)
Carrier Spacing (Hz)	8929	4464	2232	1116	558	279
Duration (T_U)	112	224	448	896	1792	3584
		DVB-T		DVB-T		

OFDM subcarriers



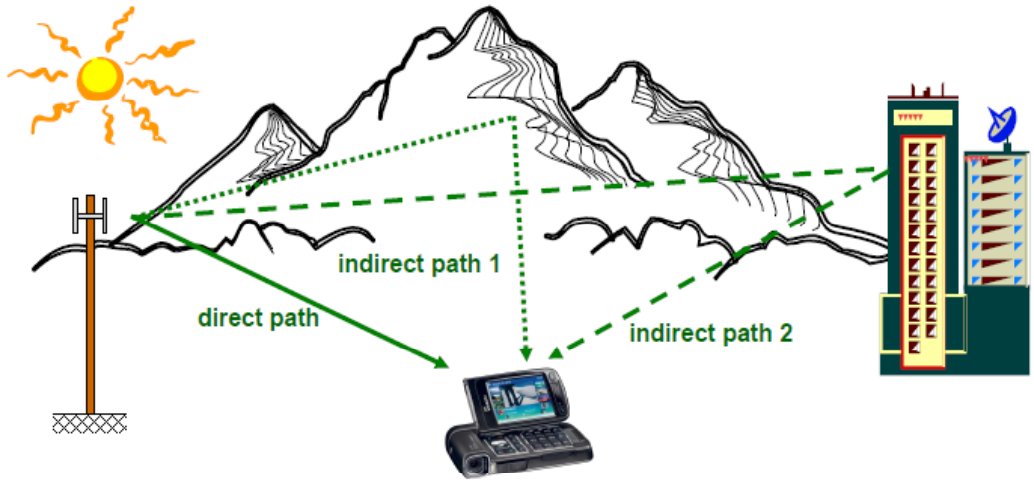
NBTC

Sin (x) / x function



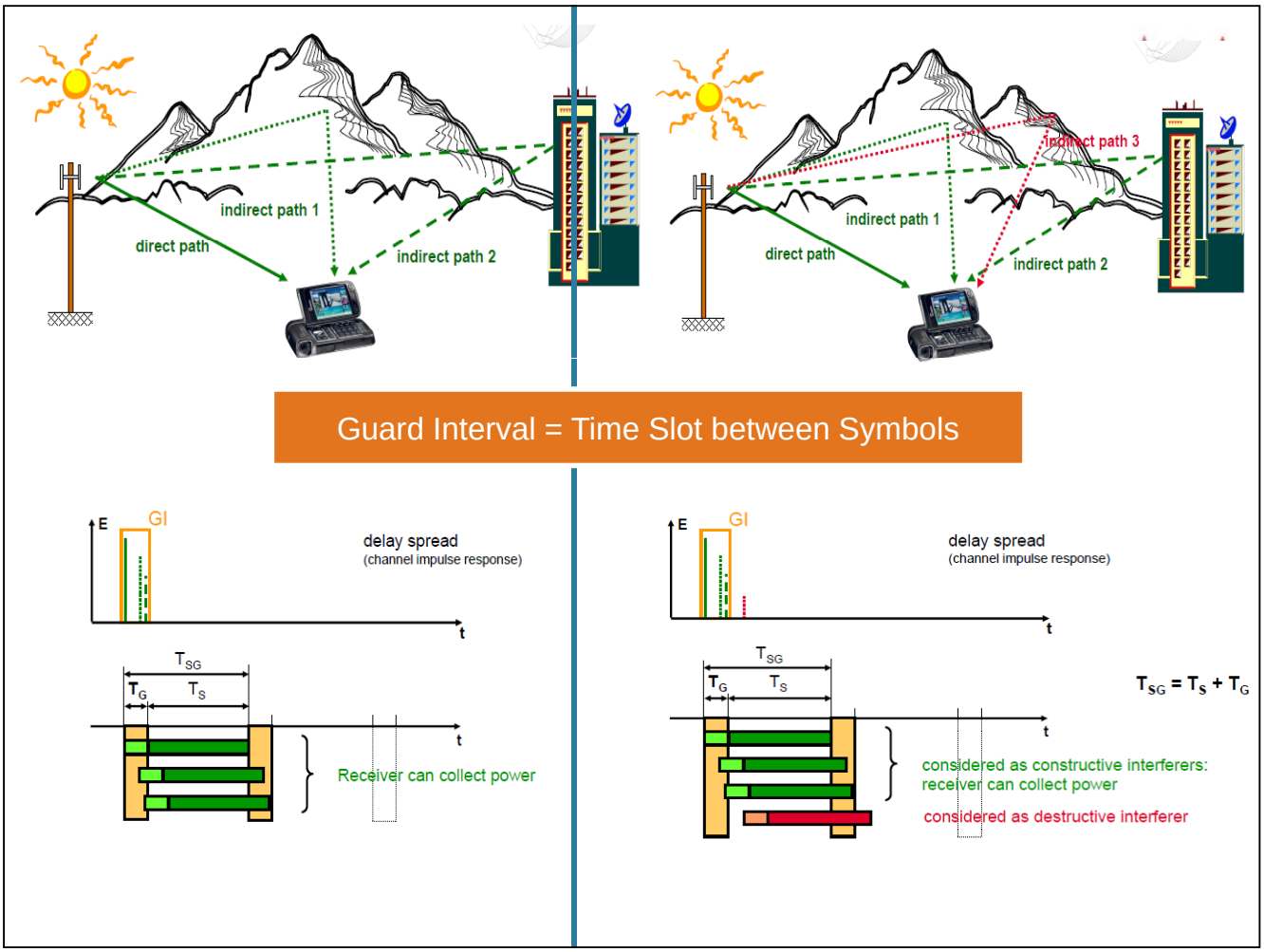
Basic OFDM

NBTC



Conventional systems consider indirect path as interferer

OFDM systems use indirect path signal to increase signal level



FFT Modes

NBTC

Δf [Hz]	T_U [μs]
8 929	112
4 464	224
2 232	448
1 116	896
558	1792
279	3584

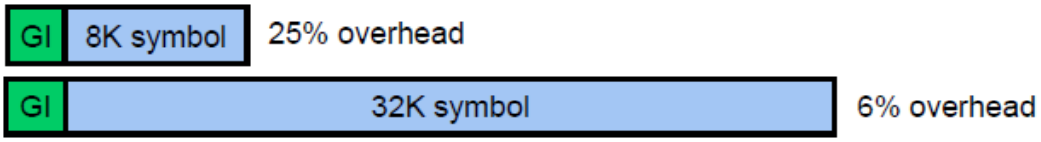
8 MHz

1K
2K ← DVB-T
4K
8K
16K
32K

Larger SFN Size
Better Impulsive Noise Tolerance
Better Mobility

Source : LS Telcom

Guard Interval



FFT size	1/128	1/32	1/16	19/256	1/8	19/128	1/4
32K	X	X	X	X	X	X	--
16K	X	X	X	X	X	X	X
8K	X	X	X	X	X	X	X
4K	--	X	X	--	X	--	X
2K	--	X	X	--	X	--	X
1K	--	--	X	--	X	--	X

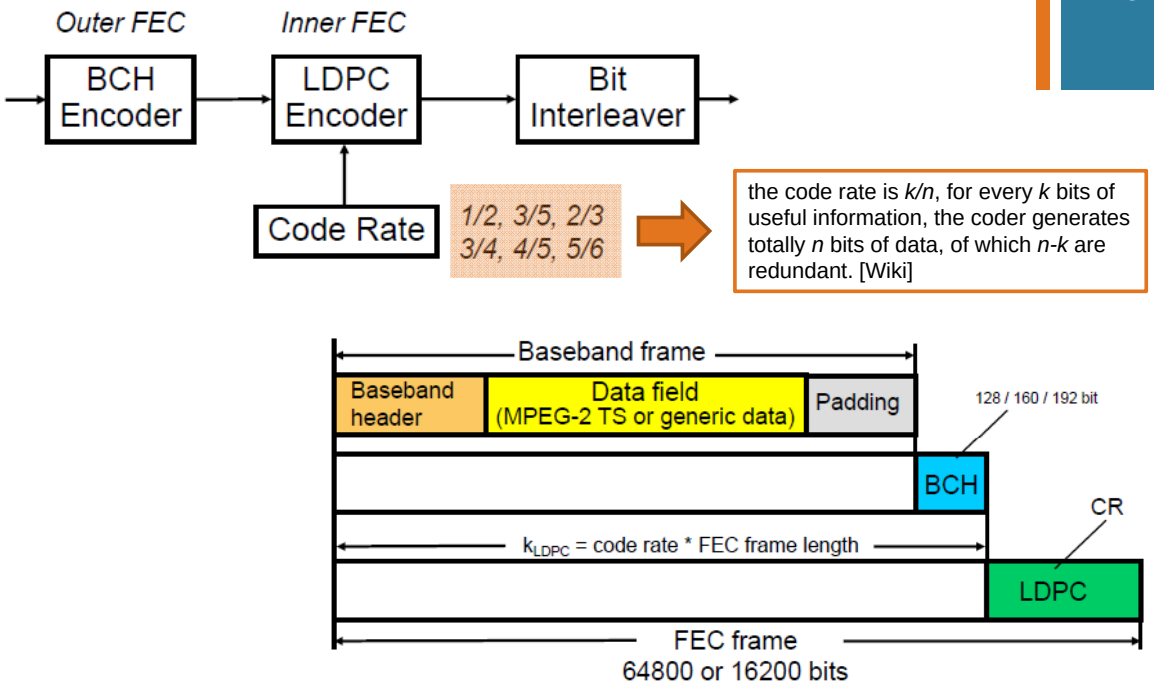
SISO Mode

Key Features of DVB-T2

Key Features of DVB-T2

1. Forward Error Correction : LDPC
2. Modulation
3. Extended Bandwidth Mode
4. Rotated Constellation
5. Pilot Patterns
6. Physical Layer Pipes (PLPs)
7. Single Frequency Network (SFN)

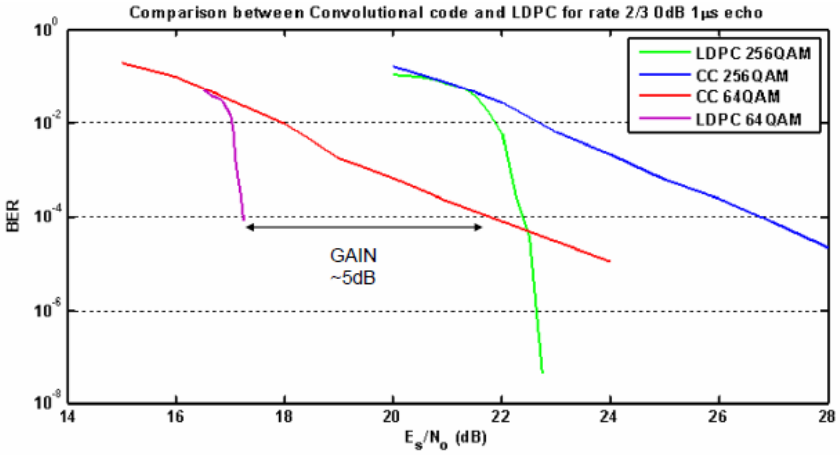
1. Forward Error Correction



BCH = Bose-Chaudhuri-Hocquenghem Code
LDPC = Low Density Parity Check Code

LDPC

- LDPC (Low Density Parity Check) error correcting codes (> 30% improvement)

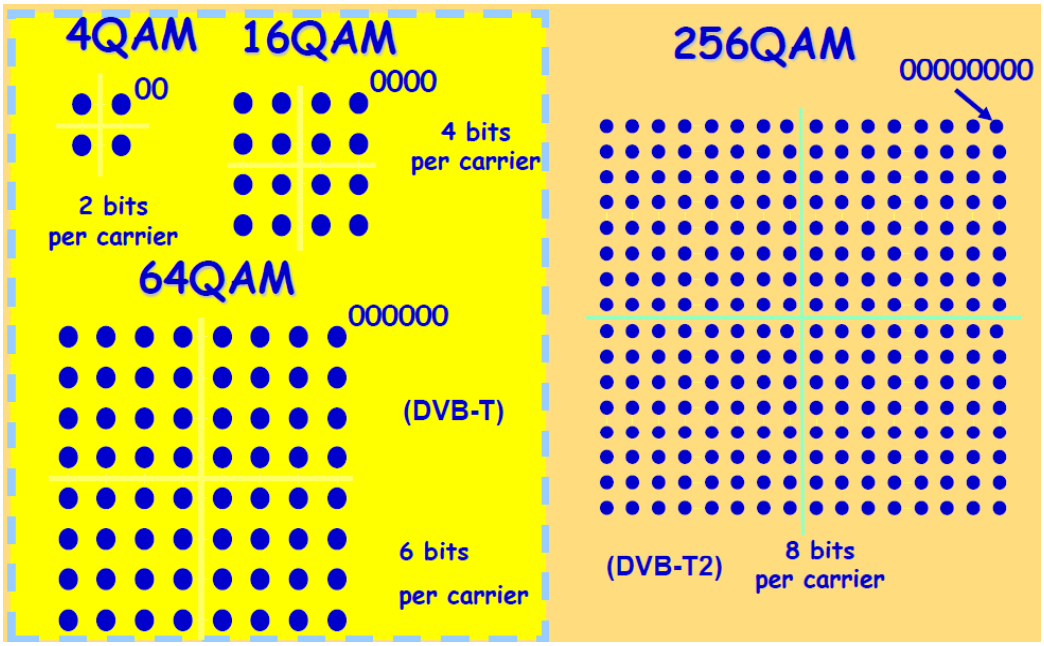


A BER of around 10-4 before Reed-Solomon is usually assumed to give "Quasi-Error-Free" (QEF) performance after Reed Solomon

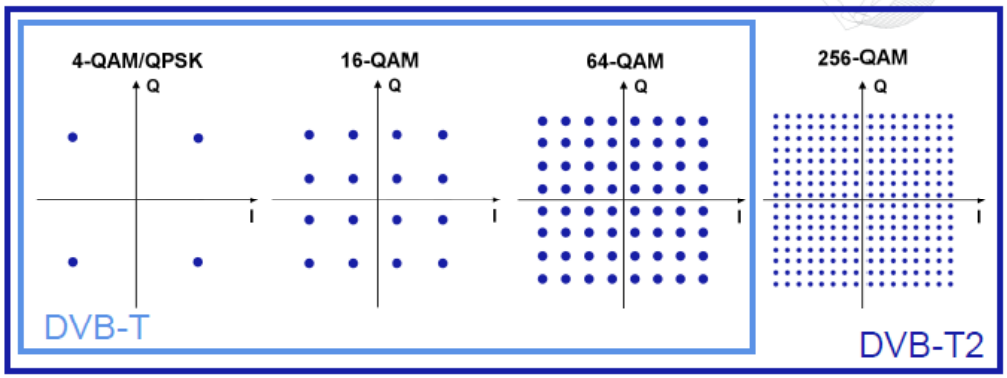
Source : DVB Bluebook A133

2. Modulation

- Higher order modulation in DVB-T2 (up to 256QAM)
- can carry up to 8 bits per carrier



Modulation (2)



Modulation Pattern	QPSK	16-QAM	64-QAM	256-QAM
Bit per symbol	2	4	6	8
DVB-T Min C/N [dB] (CR=2/3, Ricean)	7	13.1	18.6	NA
DVB-T2 Min C/N [dB] (CR=2/3, Ricean)	5.2	10.8	15.5	19.7

Implementation margin 1.5 dB

Modulation, Code Rate, and Bitrate

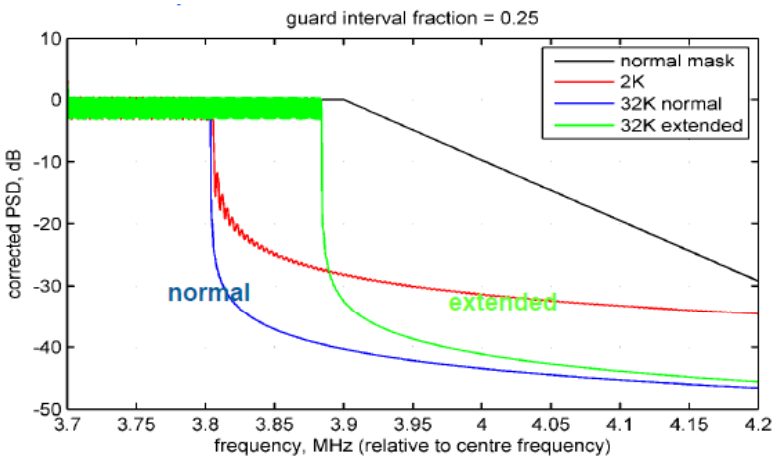
Modulation	Code rate	Bitrate (Mbit/s)
QPSK	1/2	7.4442731
	3/5	8.9457325
	2/3	9.9541201
	3/4	11.1979220
	4/5	11.9486510
	5/6	12.4565530
16-QAM	1/2	15.0374320
	3/5	18.0703800
	2/3	20.1073230
	3/4	22.6198020
	4/5	24.1362760
	5/6	25.1622360
64-QAM	1/2	22.4817050
	3/5	27.0161120
	2/3	30.0614430
	3/4	33.8177240
	4/5	36.0849270
	5/6	37.6187890
256-QAM	1/2	30.0748630
	3/5	36.1407590
	2/3	40.2146450
	3/4	45.2396040
	4/5	48.2725520
	5/6	50.3244720

@ 8MHz, 32K Mode, GI 1/128, PP7

Source : ETSI TS 102 831

3. Extended Bandwidth Mode

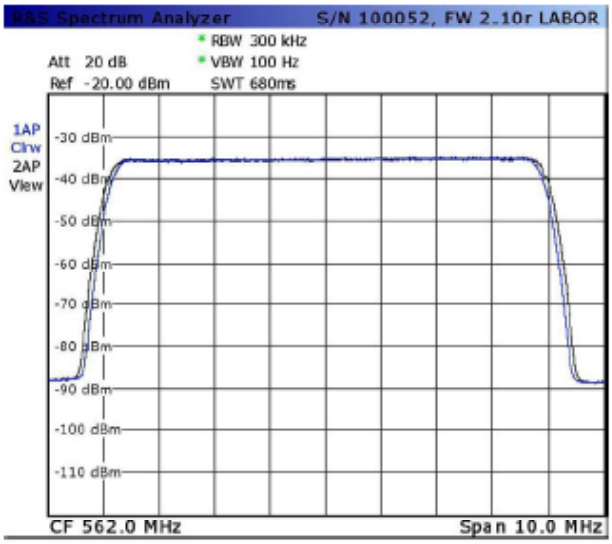
- Out-of-band spectrum for 32K mode falls away more quickly than spectrum for 2K mode
  - Allow 2% extra bandwidth/capacity whilst remaining within normal spectrum mask



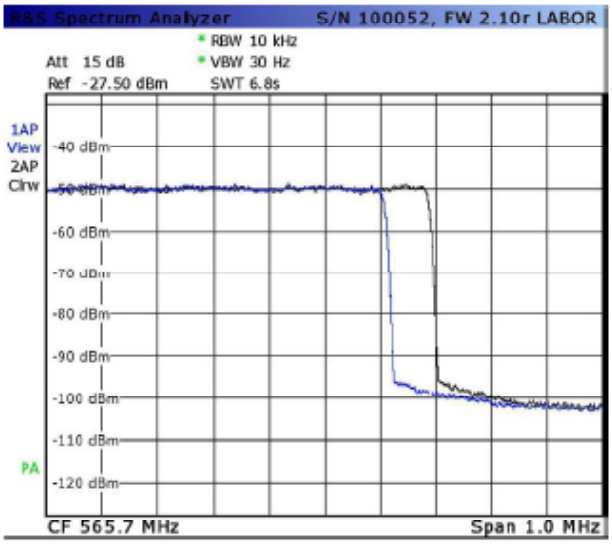
Source : ITU Workshop – BKK Feb 2012

Extended Bandwidth Mode (2)

32k and 32k extended (10 MHz Span)



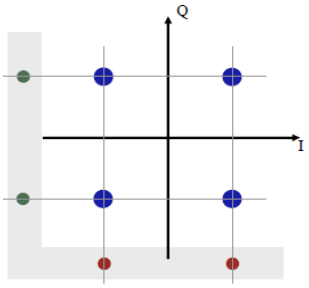
32k and 32k extended (1 MHz Span)



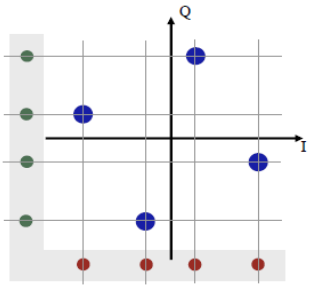
4. Rotated Constellation

- Information of bits is presented on each axis (Projection on each axis)
- Additional information for soft decision decoding
- Up to 5 dB robustness gain

QPSK cell normal



QPSK cell rotated



Cell = Mapped I/Q value

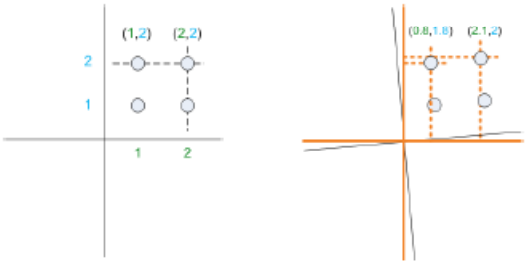
Rotation angle for each modulation type:

Mod.	QPSK	16QAM	64QAM	256QAM
Φ (°)	29.0	16.8	8.6	arctan (1/16)

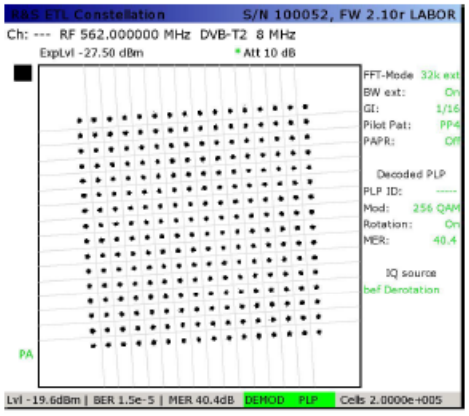
Source : LS Telcom

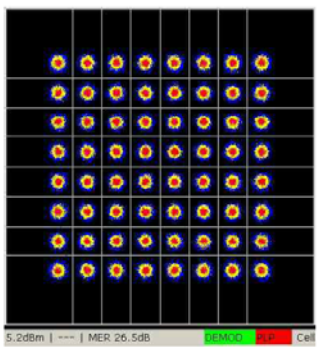
Rotated Constellation (2)

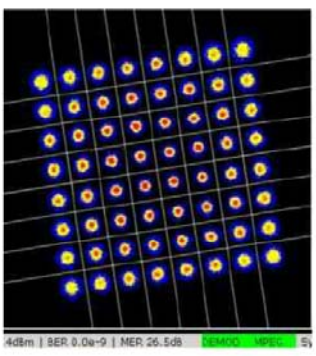
Rotating the Constellation



256 QAM - Rotated

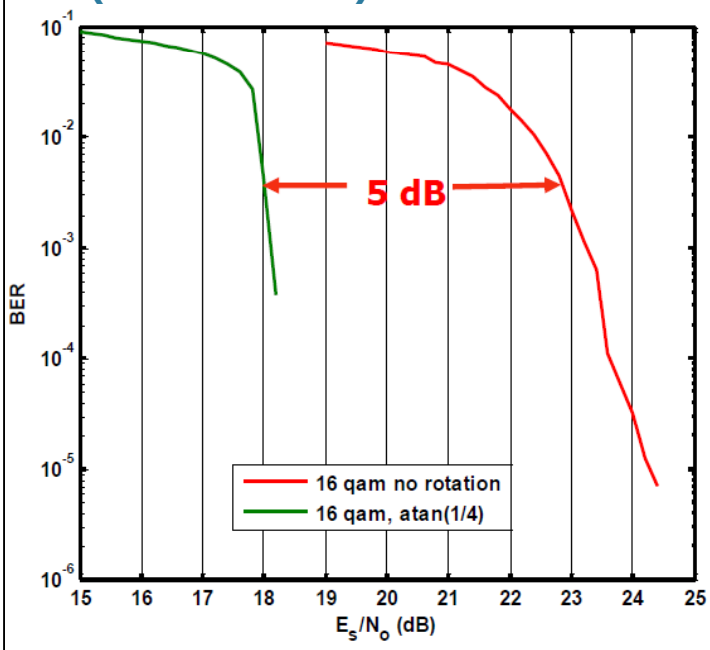






Source : Multichoice

Rotated Constellation (3)
(Robustness)



- Rotated constellations provide significantly improved robustness against loss of data cells
  - No degradation (nor gain) in Gaussian channel
  - Can achieve gains of 5-7 dB on difficult channels e.g. 15% cell loss channel
  - Can translate into increased bit rate by choosing less robust FEC with lower overhead

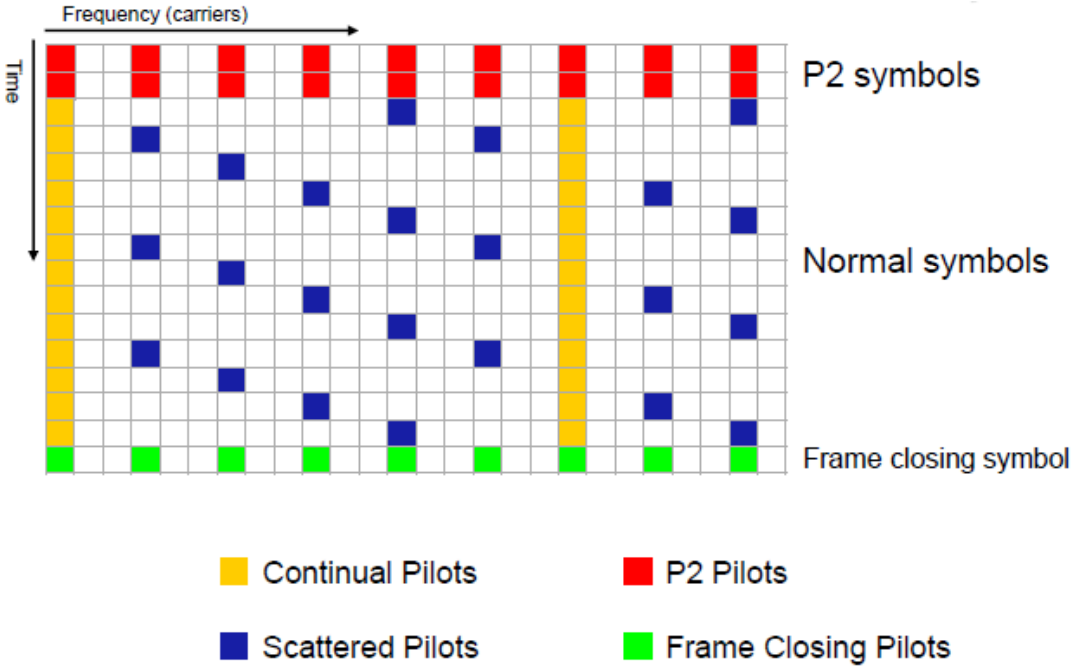
Comparison of performance for rotated/non-rotated constellations (code rate=4/5; channel = Rayleigh + 15% erasures of subcarriers)

Source : DVB Presentation

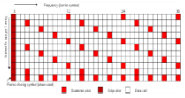
5. Pilot Pattern

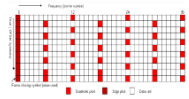
- Scattered pilots of pre-defined amplitude and phase are inserted into the signal at regular intervals in both time and frequency directions
- All of the pilots can potentially be used for synchronization
- The scattered, P2 and Frame-Closing pilots can be used for channel estimation
- The continual, P2 and Frame-Closing pilots can be used for Common-Phase-Error correction
- DVB-T only one Pattern, DVB-T2 different Pilot Patterns (PP1-PP8) are defined depending on FFT size and Guard Interval
  - Dense PP means better channel estimation – less data rate
  - Not all PPs are available for all T2 configurations (Mode and GI)

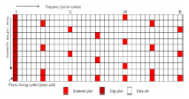
Pilot Pattern (2)

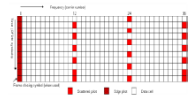


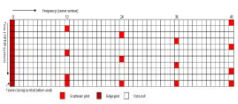
Pilot Pattern (3)

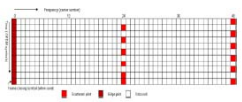
PP1 

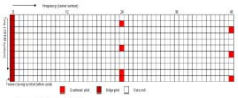
PP2 

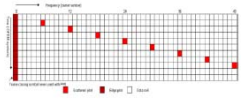
PP3 

PP4 

PP5 

PP6 

PP7 

PP8 

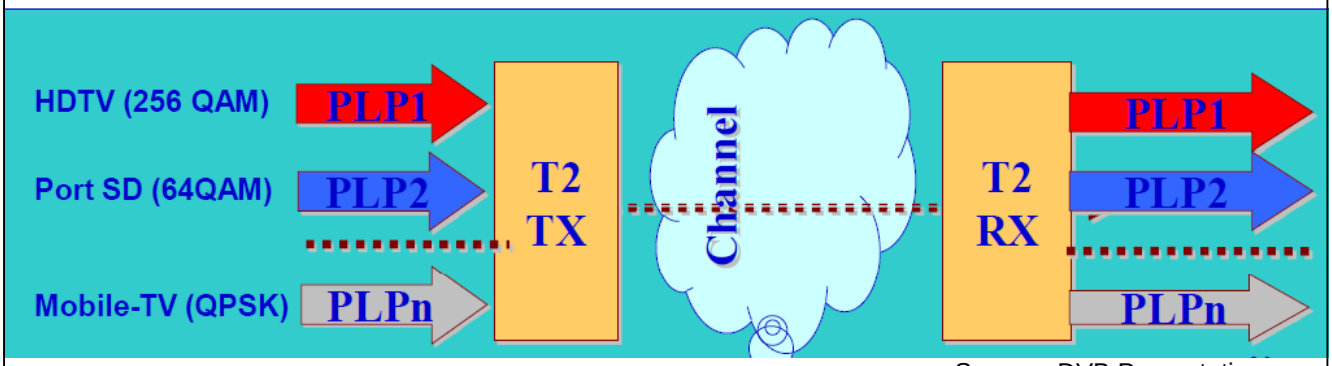
Less pilots = Less overhead

FFT size	Guard interval						
	1/128	1/32	1/16	19/256	1/8	19/128	1/4
32K	PP7	PP4 PP6	PP2 PP8 PP4	PP2 PP8 PP4	PP2 PP8	PP2 PP8	-
16K	PP7	PP7 PP4 PP6	PP2 PP8 PP4 PP5	PP2 PP8 PP4 PP5	PP2 PP3 PP8	PP2 PP3 PP8	PP1 PP8
8K	PP7	PP7 PP4	PP8 PP4 PP5	PP8 PP4 PP5	PP2 PP3 PP8	PP2 PP3 PP8	PP1 PP8
4K	-	PP7 PP4	PP4 PP5	-	PP2 PP3	-	PP1
2K	-	PP7 PP4	PP4 PP5	-	PP2 PP3	-	PP1
1K	-	-	PP4 PP5	-	PP2 PP3	-	PP1

Source : ETSI EN 302755

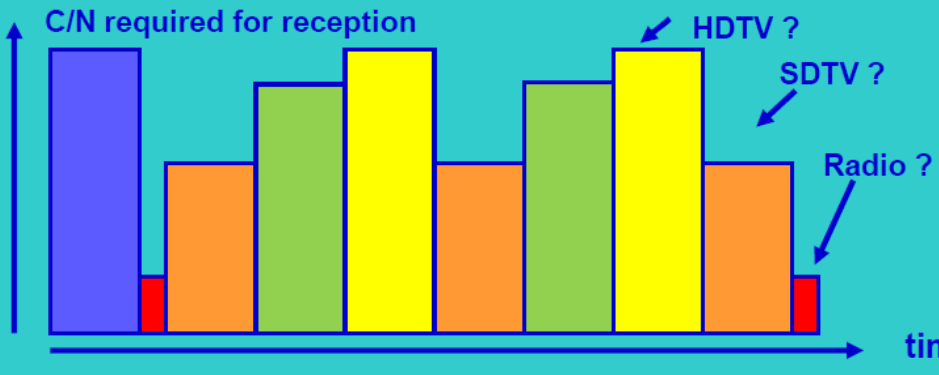
6. Physical Layer Pipes (PLPs)

- The concept of Physical Layer Pipes in DVB-T2 enables a number of services having different modulation characteristics to be transmitted through the one RF channel at the same time.
- Each input stream (PLP) is processed independently: FEC coding, mapping into constellation (QPSK, 64QAM,...) and interleaving (bit, time, frequency)
- All PLP's share same FFT, GI and pilot pattern (PP) Unless use FEF (Future Extension Frame)
- Up to 256 PLP available in one RF Channel with different C/N thresholds

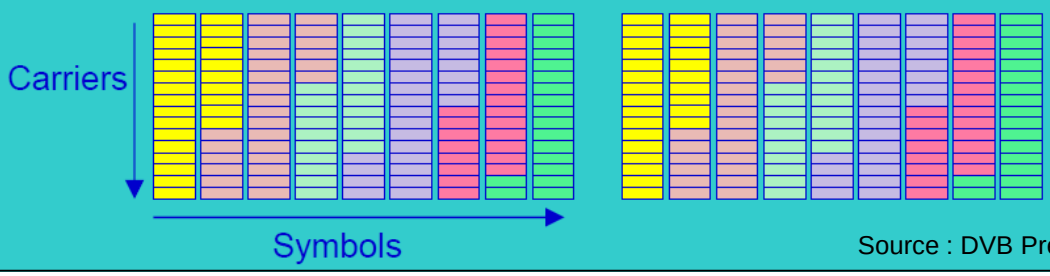


Source : DVB Presentation

Concept of PLPs



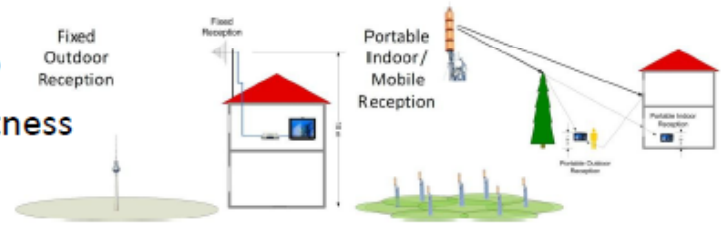
- Each slice of (data cells) is part of a Physical Layer Pipe (PLP) for that service
- Also enables power saving in the receiver

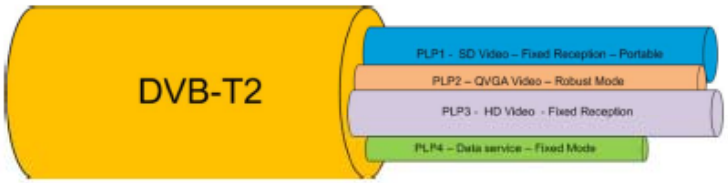


Source : DVB Presentation

Concept of PLPs

- Mode A - Single PLP
- Mode B - Multiple PLP
  - Service-specific robustness
    - Constellation
    - Codes rate
    - Time-interleaving depth
    - Time Frequency Slicing (TFS) (in Future)
  - Up to 255 PLP
  - Portable and mobile services? – (Unlikely in networks based on Fixed coverage)
  - Regionalisation solutions
  - More complex – specifically in SFN
  - T2-MI distribution

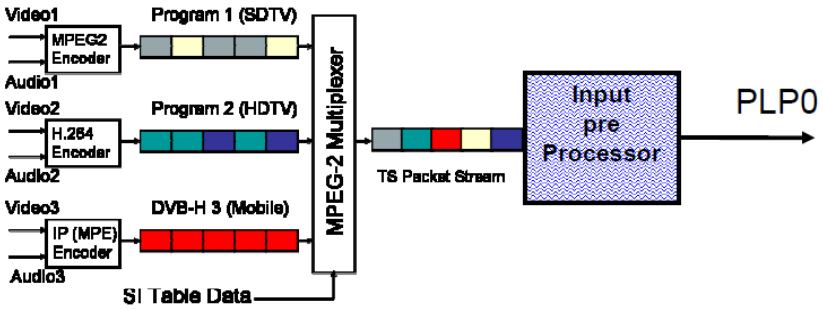




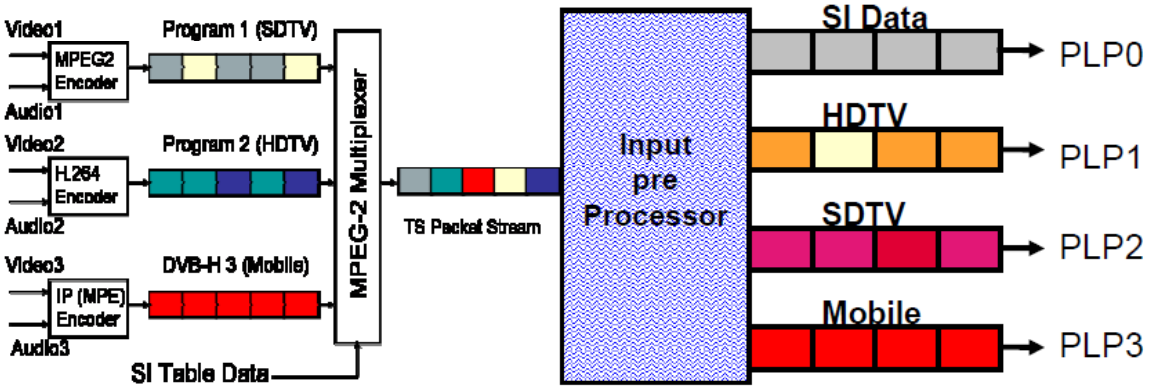
Source : Multichoice

Concept of PLPs

Mode A

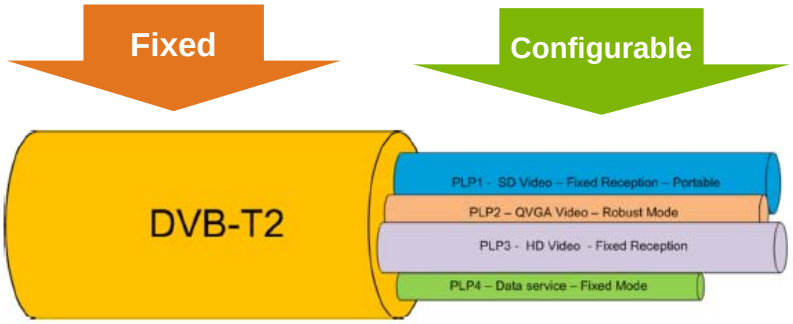


Mode B



Fixed and Configurable Parameters

Fixed Parameters per Multiplex	Configurable Parameters per PLP
Bandwidth	Constellation (QAM)
Carrier Mode	Rotated Constellation
Pilot Pattern	Code Rate
Guard Interval	Interleaving
PAPR	
MISO	

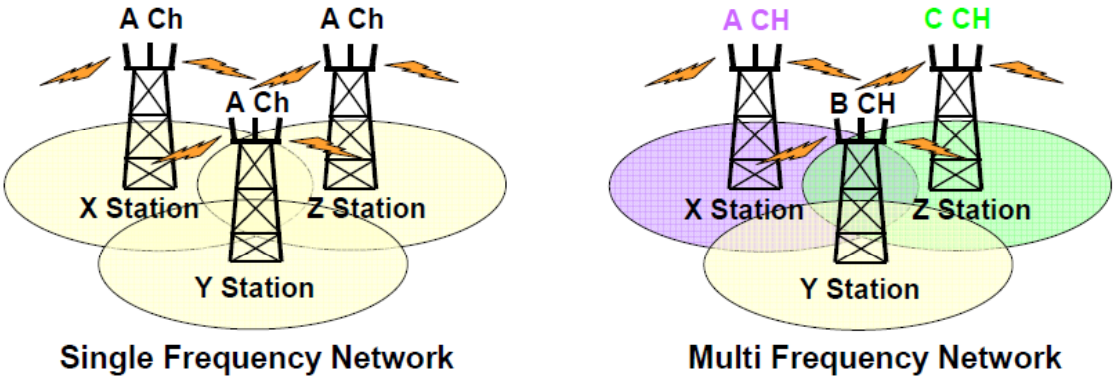


Source : LS Telcom

MPLP Demo at Broadcast Asia 2011

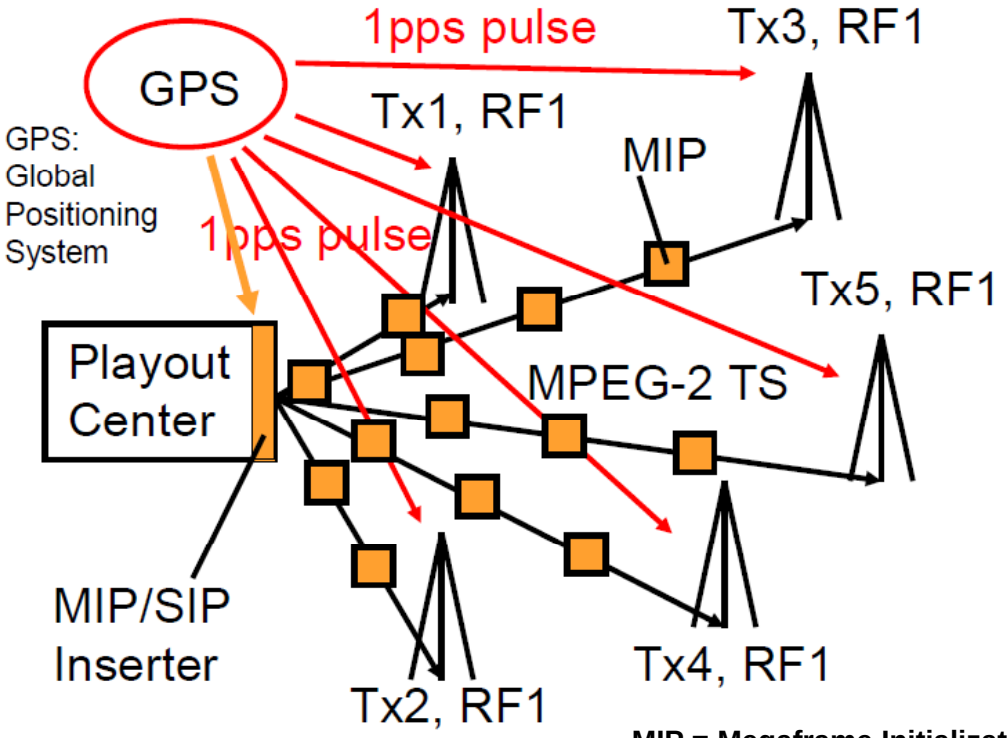
Source : DVB Presentation

7. Single Frequency Network (SFN)



- Single Frequency Network (SFN) is a network of synchronized transmitter stations radiating identical signal in the same RF channel (defined in GE06, p46)

Synchronization

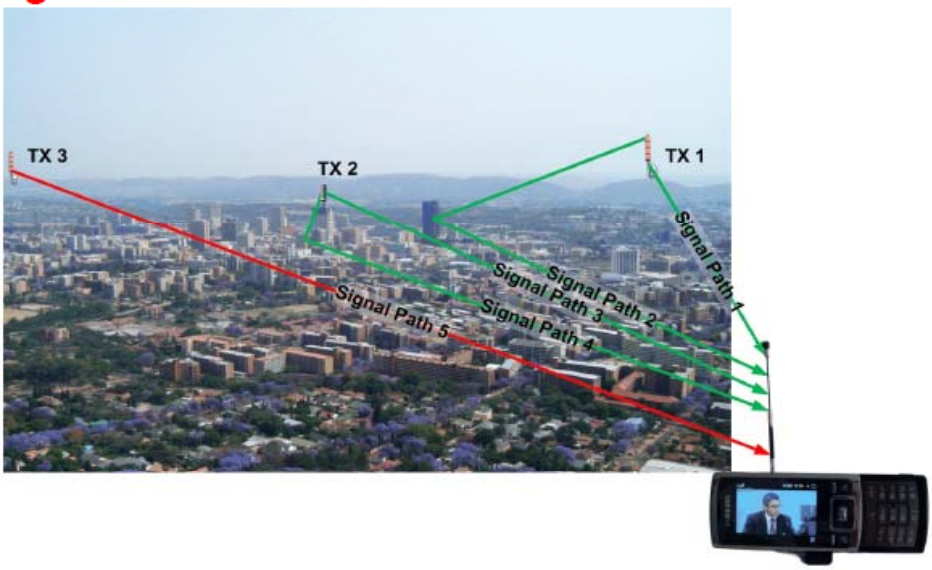


MIP = Megaframe Initialization Packet

What makes SFN operation possible

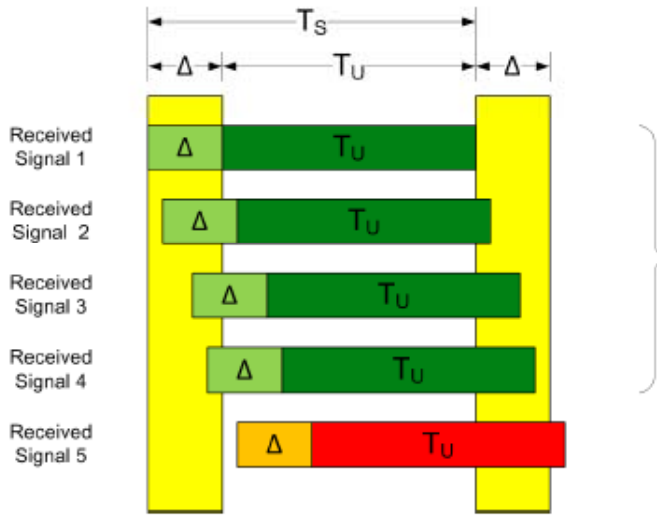
- Clocked transmission
- Time- and Frequency Synchronization
- Provision of a Guard Interval

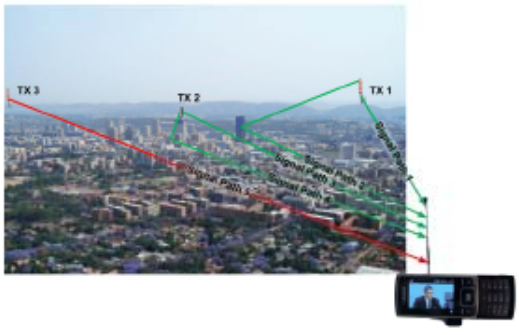
Signals in a SFN



Signals in SFN

Signals in a SFN





Signals arriving within guard interval are considered as constructive

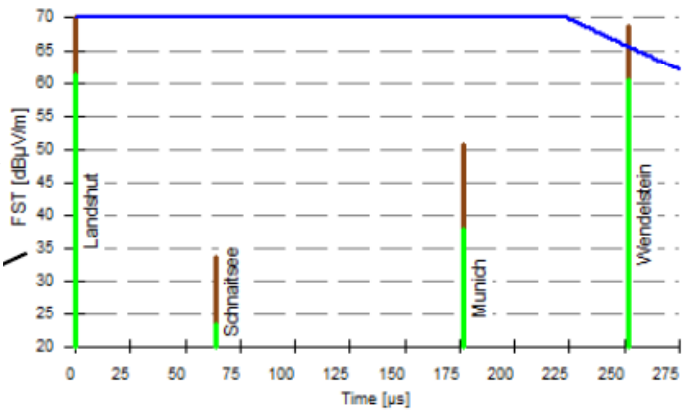
Signals arriving after the guard interval are destructive interferers

Self interference

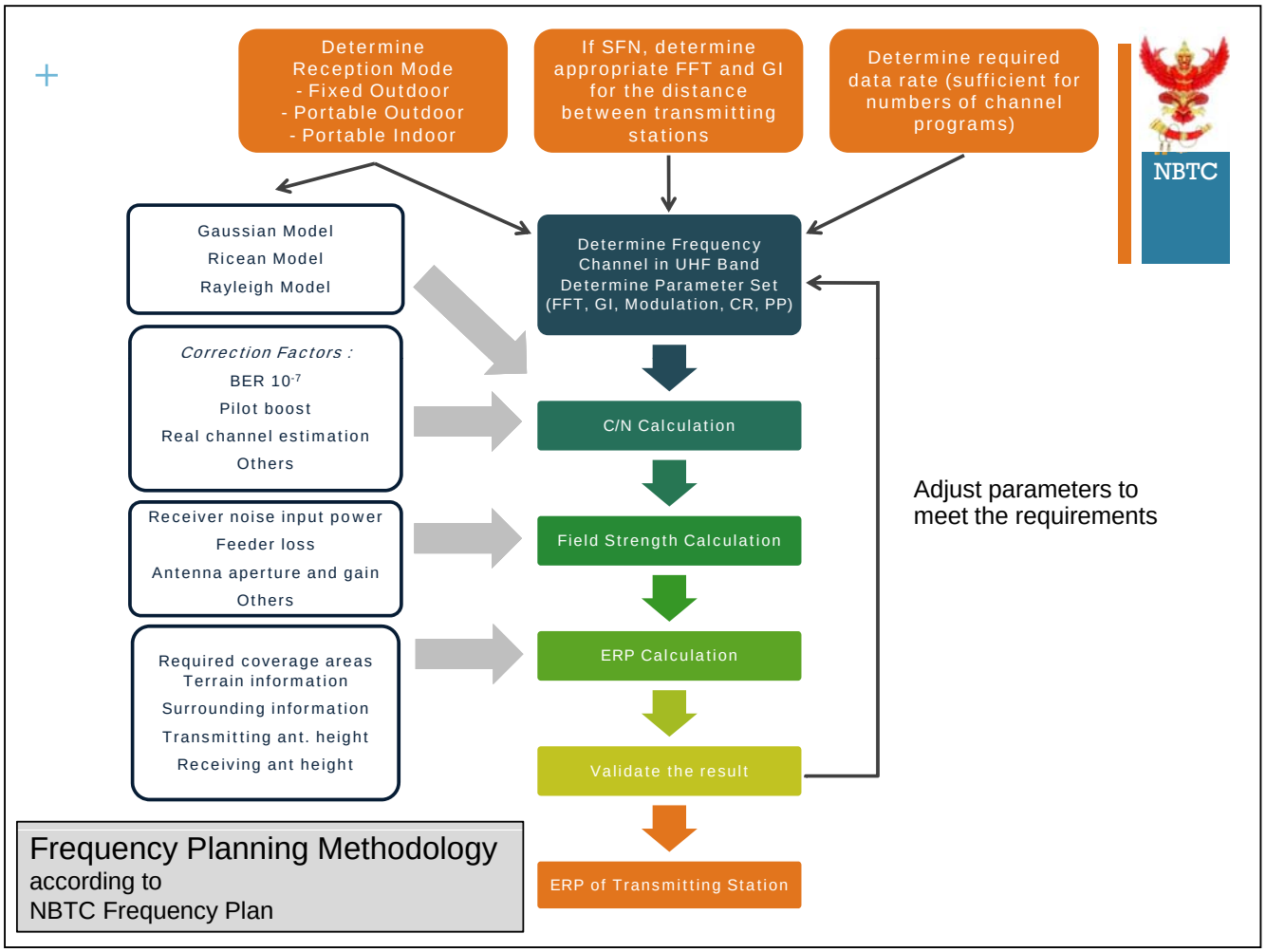
Source : Multichoice

SFN Network

- โครงข่ายแบบ SFN ถือได้ว่ามีจุดเด่นเรื่องประสิทธิภาพการใช้งานคลื่นความถี่อย่างมาก เนื่องจากใช้ทรัพยากรคลื่นความถี่น้อยลง
- แต่ก็ยังมีข้อจำกัดเรื่องของการรบกวนแบบ self-interference หรือ inter-symbol interference ซึ่งเกิดจากสัญญาณจากแต่ละสถานีส่งมาถึงเครื่องรับในเวลาไม่พร้อมกันและออกนอกกรอบเวลาของ guard interval
- ดังนั้นโครงข่ายแบบ SFN ซึ่งอาศัยเทคโนโลยี COFDM จึงมีข้อจำกัดในเรื่องของระยะห่างสูงสุดของเครื่องส่ง เพื่อให้แน่ใจว่าสัญญาณจากแต่ละแหล่งที่ไปถึงแต่ละจุดของเขตบริการยังอยู่ในกรอบเวลาของ guard interval



DVB-T2 Planning

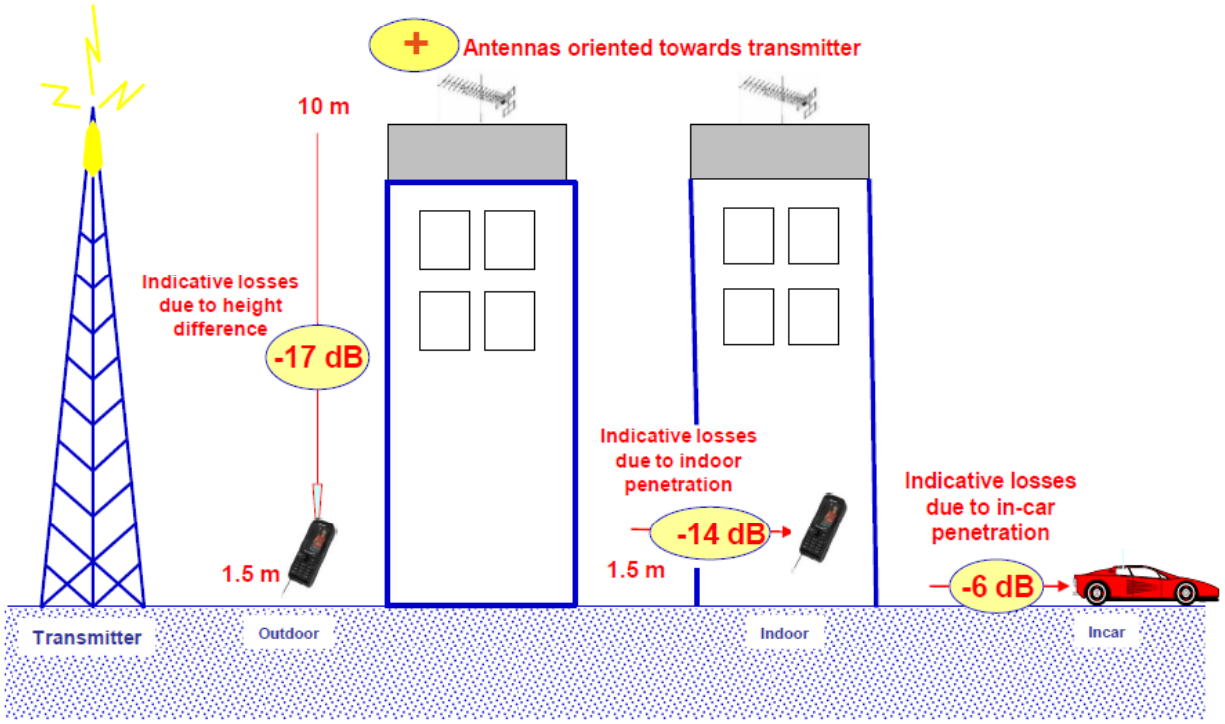


DVB-T2 Planning

NBTC

- Reception Mode
  - Fixed Rooftop
  - Portable Outdoor
  - Portable Indoor
- Parameter Set
- Capacity Planning
  - Capacity vs Robustness
- Coverage Planning (Required C/N and Required FS)
- Interference and Protection Ratio

Reception Mode



Parameter Set

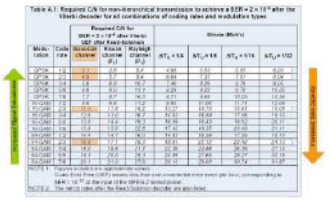
ขนาด FFT (FFT Size)	สัดส่วนช่วงเวลาป้องกัน (Guard Interval Fraction)
1k	1/16, 1/8, 1/4
2k	1/32, 1/16, 1/8, 1/4
4k	1/32, 1/16, 1/8, 1/4
8k	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4
16k	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4
32k	1/128, 1/32, 1/16, 19/256, 1/8, 19/128
8k extended	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4
16k extended	1/128, 1/32, 1/16, 19/256, 1/8, 19/128, 1/4
32k extended	1/128, 1/32, 1/16, 19/256, 1/8, 19/128

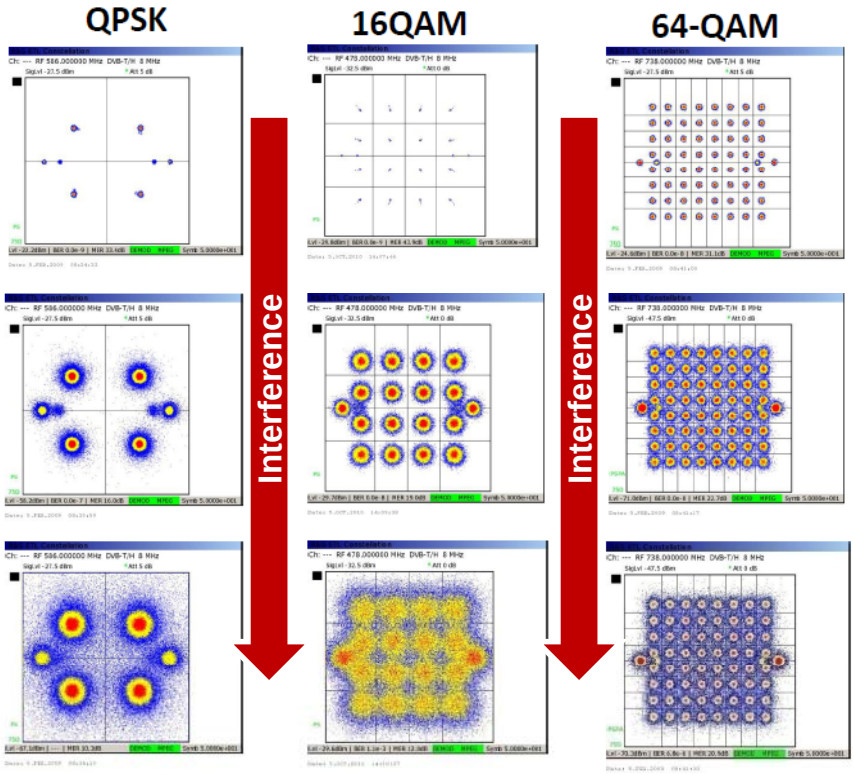
การมอดูเลตสัญญาณ (Modulation)	อัตราการเข้ารหัส (Code Rate)
QPSK หรือ 16-QAM หรือ 64-QAM หรือ 256-QAM	1/2, 3/5, 2/3, 3/4, 4/5, 5/6

ขนาด FFT	สัดส่วนช่วงเวลาป้องกัน (Guard Interval Fraction)						
(FFT Size)	1/128	1/32	1/16	19/256	1/8	19/128	1/4
32K	PP7	PP4 PP6	PP2 PP8 PP4	PP2 PP8 PP4	PP2 PP8	PP2 PP8	
16K	PP7	PP7 PP4 PP6	PP2 PP8 PP4 PP5	PP2 PP8 PP4 PP5	PP2 PP3 PP8	PP2 PP3 PP8	PP1 PP8
8K	PP7	PP7 PP4	PP8 PP4 PP5	PP8 PP4 PP5	PP2 PP3 PP8	PP2 PP3 PP8	PP1 PP8
4K		PP7 PP4	PP4 PP5		PP2 PP3		PP1
2K		PP7 PP4	PP4 PP5		PP2 PP3		PP1
1K		-	PP4 PP5		PP2 PP3		PP1

Capacity vs Robustness

- Robustness
  - data capacity (no. channels) against
  - transmitter power level (or network cost)
- Modulation
  - Method of shaping the signal with the data to be broadcast e.g. QPSK, 16 QAM, 64 QAM
  - Determines the capacity of a network (number of channels)
  - Higher order Modulation
    - Delivers more channels
    - More critical
    - Requires more signal (C/N)
    - Higher cost





Capacity vs Robustness (2)

To have same coverage, higher order modulation requires higher tx power

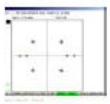


Table A.1: Required C/N for non-hierarchical transmission to achieve a BER = 2×10^{-4} after the Viterbi decoder for all combinations of coding rates and modulation types

Modulation	Code rate	Required C/N for BER = 2×10^{-4} after Viterbi QEF after Reed-Solomon: Gaussian channel	Ricean channel (F_1)	Rayleigh channel (P_1)	Bitrate (Mbit/s): ΔT	ΔT_U = 1/8	ΔT_U = 1/16	ΔT_U = 1/32
QPSK	1/2	3,1	3,6	5,4	4,98	5,53	5,85	6,03
QPSK	2/3	4,9	5,7	8,4	6,64	7,37	7,81	8,04
QPSK	3/4	5,9	6,8	10,7	7,46	8,29	8,78	9,05
QPSK	5/6	6,9	8,0	13,1	8,29	9,22	9,76	
QPSK	7/8	7,7	8,7	16,3	8,71	9,68	10,25	10,56
16-QAM	1/2	8,8	9,6	11,2	9,95	11,06	11	12,06
16-QAM	2/3	11,1	11,6	14,2	13,27	14,75	61	16,09
16-QAM	3/4	12,5	13,0	16,7	14,93	16,59	17,56	18,10
16-QAM	5/6	13,5	14,4	19,3	16,59	18,43	19,52	20,11
16-QAM	7/8	13,9	15,0	22,8	17,42	19,35	20,49	21,11
64-QAM	1/2	14,4	14,7	16,0	14,93	16,59	17,56	18,10
64-QAM	2/3	16,5	17,1	19,3	19,91	22,12	23,42	24,13
64-QAM	3/4	18,0	18,6	21,4	22,39	24,88	26,35	27,14
64-QAM	5/6	19,3	20,0	25,3	24,88	27,65	29,27	30,16
64-QAM	7/8	20,1	21,0	27,9	26,13	29,03	30,74	31,67

NOTE 1: Figures in italics are approximate values.
Quasi Error Free (QEF) means less than one uncorrected error event per hour, corresponding to BER = 10^{-11} at the input of the MPEG-2 demultiplexer.
NOTE 2: The net bit rates after the Reed-Solomon decoder are also listed.

Increased Signal Robustness

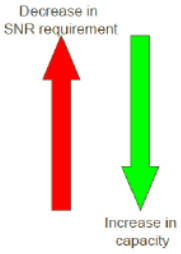
Increased Data Capacity

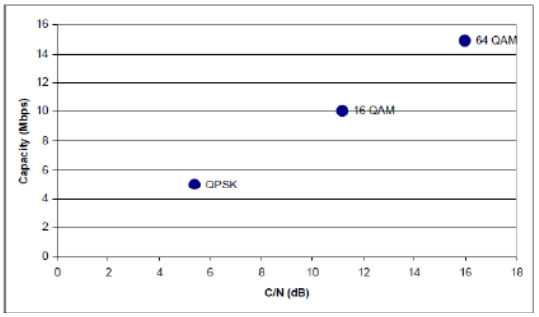
Adapted from source: ETSI EN 300744, available for download at www.etsi.org

สรุปผลของการปรับค่าพารามิเตอร์

Modulation Scheme

- QPSK (2 bits/symbol)
- 16QAM (4 bits/symbol)
- 64QAM (6 bits/symbol)

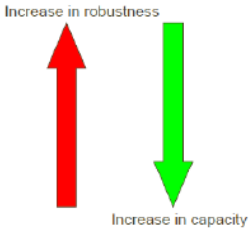


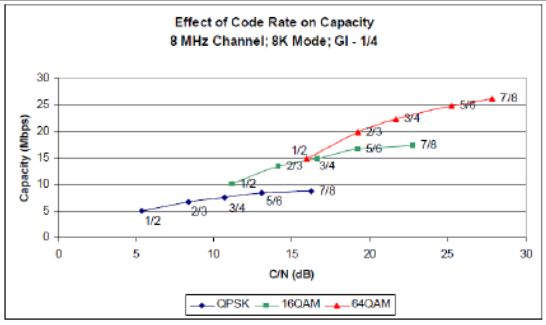


8 MHz BW, 8K FTT size, ¼ GI, ½ code rate

Error Correction (อัตราส่วนข้อมูลจริงต่อข้อมูลที่ถูกส่ง)

- 1/2
- 2/3
- 3/4
- 5/6
- 7/8





C/N figures based on a Rayleigh channel

Note : From DVB-T

สรุปผลของการปรับค่าพารามิเตอร์ (2)

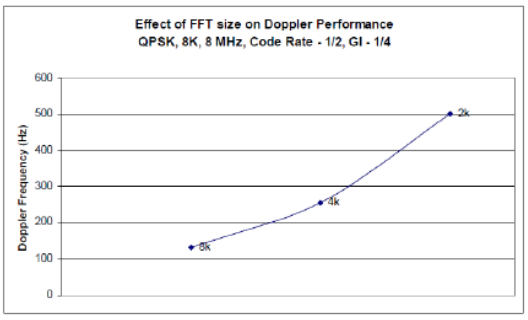
FTT Size

(maximum number of carriers modulated within the channel bandwidth 7MHz or 8MHz)

8K = 8096 potential carriers

2K = 2048 potential carriers

** จำนวน carrier จะทำให้รู้ระยะระหว่างcarrier (carrier spacing) ซึ่งมีผลต่อประสิทธิภาพขณะเคลื่อนที่ เนื่องจาก Doppler shift จะส่งผลให้เกิด inter-carrier interference



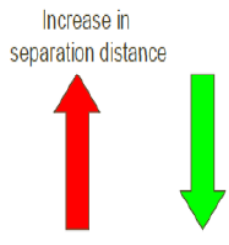
More FTT size = more SFN Tx separation distance.

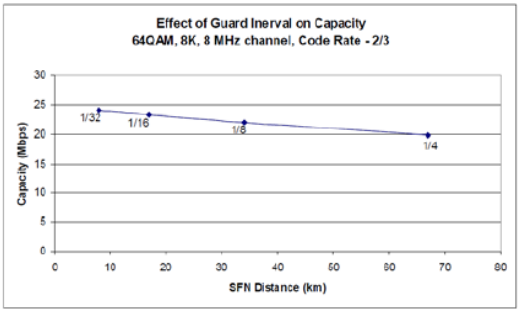
Less FTT size = more Doppler performance (better for mobile)

Guard Interval – Extension of symbol

(อัตราส่วนของ GI ต่อช่วงเวลาทั้งหมดในการส่งหนึ่งสัญลักษณ์)

- 1/4
- 1/8
- 1/16
- 1/32





Longer symbol period to combat multipath effect

Note : From DVB-T

Coverage Planning

* อ้างอิงค่าจาก EBU Tech 3348

NBTC

รายการ	รูปแบบของการรับสัญญาณ (Reception mode)		
	Fixed	Portable outdoor	Portable Indoor
ความถี่วิทยุ	650 MHz	650 MHz	650 MHz
พารามิเตอร์ของระบบ DVB-T2	256-QAM, FEC 2/3, 32k Extended, PP7	64-QAM, FEC 2/3, 32k Extended, PP4	64-QAM, FEC 2/3, 16k Extended, PP1
อัตราบิตโดยประมาณ	33-40 Mbit/s	26-29 Mbit/s	23-28 Mbit/s
อัตราส่วนคลื่นพาห์ต่อสัญญาณรบกวนที่ต้องการ (C/N)	20.0 dB	17.9 dB	18.3 dB
เปอร์เซ็นต์ของพื้นที่ครอบคลุมที่ต้องการ	95%	95%	95%
ค่าเทียบเท่าความแรงสนามไฟฟ้าต่ำสุดที่ต้องการ ณ จุดรับสัญญาณ (E_{med}) โดยประมาณ	54.3 dBµV/m	60.2 dBµV/m	75.9 dBµV/m

ระยะทางสูงสุดที่ต้องการ + แบบจำลองการแพร่กระจายคลื่น (propagation model) => กำลังส่งออกอากาศของสถานี

หรือ

กำลังส่งออกอากาศของสถานี + แบบจำลองการแพร่กระจายคลื่น (propagation model) => ระยะทางสูงสุดที่สามารถรับสัญญาณ

Required C/N and Required Field Strength

Calculations and Methodologies are based on NBTC Frequency Plan (Reference : EBU Tech 3348)

NBTC

โดย กลุ่มงานมาตรฐานและเทคโนโลยีกระจายเสียงและโทรทัศน์
สำนักงานคณะกรรมการกิจการกระจายเสียง กิจการโทรทัศน์ และกิจการโทรคมนาคมแห่งชาติ

การคำนวณค่าความแรงสนามไฟฟ้าสมมูลต่ำสุดที่ต้องการของการรับสัญญาณลักษณะต่างๆ

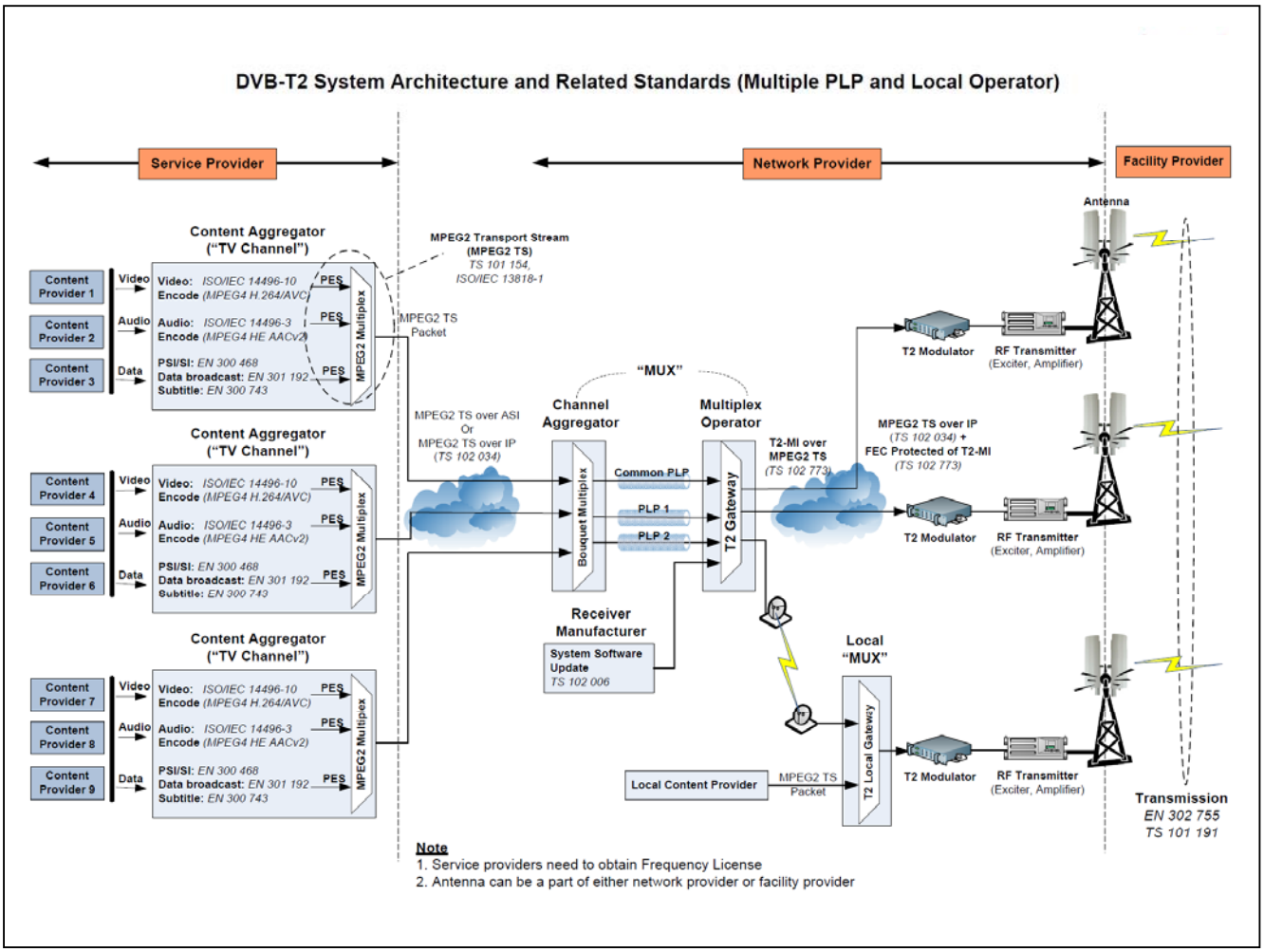
Pilot Pattern	3
Constellation	256-QAM
Code Rate	2/3
Center Frequency (MHz)	514
Bandwidth (MHz)	7.77

ลำดับ	รายการ	สัญลักษณ์	หน่วย	รูปแบบของการรับสัญญาณ (Reception mode)			การคำนวณ
				Fixed	Portable outdoor	Portable Indoor	
1	ความถี่วิทยุ (Frequency)	f	MHz	650	650	650	
2	อัตราส่วนคลื่นพาห์ต่อสัญญาณรบกวนที่ต้องการ (Minimum C/N Required by System)	C/N	dB	20.78	22.96	22.96	ค่าจากการคำนวณตามวิธีในข้อ ๔ ของภาคผนวกตามแผนความถี่วิทยุฯ
3	ตัวเลขแสดงสัญญาณรบกวนของเครื่องรับ(Receiver Noise Figure)	F	dB	6	6	6	
4	แบนด์วิดท์สมมูลของสัญญาณรบกวน(Equivalent Noise Bandwidth)	B	MHz	7.77	7.77	7.77	
5	กำลังของสัญญาณรบกวนขาเข้าในเครื่องรับ (Receiver Noise Input Power)	P_n	dBW	-129.07	-129.07	-129.07	$P_n = F + 10 \log (k \cdot T_0 \cdot B)$
6	กำลังต่ำสุดของสัญญาณขาเข้าในเครื่องรับ (Min. Receiver Signal Input Power)	$P_{s\,min}$	dBw	-108.29	-106.11	-106.11	$P_{s\,min} = P_n + C/N$
7	ค่าแรงดันไฟฟ้าสมมูลต่ำสุดที่ขาเข้าของเครื่องรับซึ่งมีอิมพีแดนซ์ขาเข้า 75 โอห์ม (Min. Equivalent Receiver Input Voltage, 75 ohms)	U_{min}	dBµV	30.45759366	32.63759366	32.63759366	$U_{min} = P_{s\,min} + 120 + 10 \log (Z_i)$

NBTC Notifications on Technical Standards

- ประกาศ กสทช. เรื่อง มาตรฐานทางเทคนิคสำหรับการให้บริการโทรทัศน์ภาคพื้นดินในระบบดิจิตอล
- ประกาศ กสทช. เรื่อง มาตรฐานทางเทคนิคสำหรับเครื่องรับสัญญาณโทรทัศน์ภาคพื้นดินในระบบดิจิตอล

NBTC Notification on Technical Standard for DTTB Transmission



Summary of

NBTC Technical Standard on DTTB Transmission

NBTC

- Scope :

  Minimum requirement for equipments in free-to-air DVB-T2 transmission systems

- Frequency Range :

  510-790 MHz with 8 MHz Bandwidth

- Baseband signal and compression

  Video coding : MPEG-4 AVC/H.264

  SD 576i | HD 720p | HD 1080i

  Audio coding : MPEG-4 HE-AACv2

- Transmission

  Framing Structure, Channel Coding and Modulation : ETSI EN 302 755

  Single Frequency Network : ETSI TS 101 191

Summary of
NBTC Technical Standard on DTTB Transmission (2)

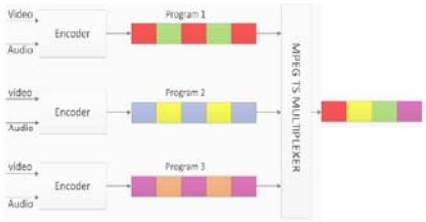
- Multiplexing

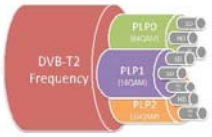
  Service Information (SI) : ETSI EN 300 468

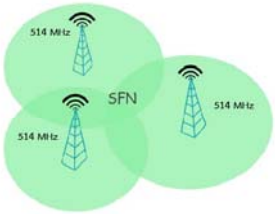
  Data Broadcasting : ETSI EN 301 192

  MPEG-2 Transport Stream : ETSI TS 101 154

  Modulator Interface (T2-MI) (if any SFN or MPLP opreration) : ETSI TS 102 773







- System Software Update: SSU : ETSI TS 102 006
- Subtitling : ETSI EN 300 743
- Measurement Methods : ETSI TR 101 290/DVB Document A14-2

NBTC Notification on Technical Standard for DTTB Receiver

Summary of
NBTC Technical Standard on DTTB Receiver

NBTC

The DTTB Standard Structure of Set-Top-Box and iDTV

IDTV

Set-Top-Box

1. Scope
2. General Requirements
8. System Software Update
7. Service Information and Display
6. Video and Audio Decoding
   - Video: MPEG4 AVC/h264
   - Audio: MPEG4 HE AACv2
5. De-multiplexing and Transport Stream
4. RF Tuner and Decoder Requirement
   - Radio frequency requirement
   - DVB-T2 Operating Mode
3. Connector and Interface
   - RF connector
   - Video and audio connector
   HDMI

Based on Specification from Malaysia and Singapore and Draft ASEAN Common Specification

Summary of
NBTC Technical Standard on DTTB Receiver (2)

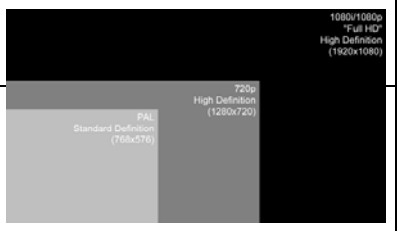
NBTC

1.Scope	 iDTV  Set-top-box	
2. General Requirements	2.1 Electrical Safety: TIS.1195-2536	
	2.2 Electromagnetic Compatibility: CISPR13/TIS.2185-2547	
	2.3 Installation and Usage: Must supply with installation manual and instruction manual both Thai and English language	
	2.4 Remote Control: Must supply with remote control with the tactile marking on the '5' button	

Summary of
NBTC Technical Standard on DTTB Receiver (3)

NBTC

3. Connectors and Interfaces)	   RF Input Connector/RF Loop-through | RCA | HDMI
4. RF Tuner and Decoder Requirements	4.2 Radio Frequency Requirements 470-862 MHz | BW 8 MHz | NF < 6dB Sensitivity < -78.3 dBm | off-set ± 125KHz
	4.2 DVB-T2 Operating Modes ETSI EN 302 755 Support MPLP and SFN
5. De-multiplexing and Transport Stream	ETSI TS 101 154 ISO/IEC 13818-1
6. Video and audio	Video coding : MPEG-4 AVC/H.264 Resolution : SD 576i | HD 720p/1080i AFD (Active Format Description) Audio coding : MPEG-4 HE-AACv2



Summary of
NBTC Technical Standard on DTTB Receiver (4)

NBTC

7. Processing and Display	7.1 Processor and Memory DDRAM ≥ 64 MB | Flash ≥ 8MB | Processor ≥ 300 MHz
	7.2 Character set): ETSI EN 300 468 Table 00 and Table 07
	7.3 On Screen Display: OSD : Thai and English
	7.4 Subtitling system : ETSI EN 300 743 and support DDS (Display Definition Segment)
	7.5 Multi-Language Support : THA | ENG | QAA
	7.6 Services and Channel Number: 1-799 for National service (ONID 0x22FC) 800-999 for other services
	7.7 Logical Channel Descriptor
	7.8 Electronic Program Guide: EPG : shall restore program information for next 7 days
	7.9 Signal Strength and Signal Quality
8. System Software Update: SSU	ETSI TS 102 006

NBTC Notification on DTTB Frequency Plan

Summary of NBTC Technical Standard on DTTB Frequency Plan

- In accordance with Thailand's Table of Frequency Allocation

Allocation to services	
Thailand	Footnotes
510-790 BROADCASTING Fixed Mobile 5.149 5.306 5.311A	T-unlicensed2 T-TV

- Bandwidth 8 MHz
- Frequency channel number : Channel No. 26 to 60 (Total 35 Channels)
- 39 service areas, consist of 39 main stations and 114 gap-filling stations
- 5 multiplexes (MUX) per service area (during simulcast period)

Summary of NBTC Technical Standard on DTTB Frequency Plan (2)

35 channels are divided into 6 groups (D1-D6), plus 2 special groups (T-D1-T-D2)

Group	*#Channels in each group*	*Channel for DTTB in each group*															
		N-3	N	N+3	N+4	N+6	N+7	N+8	N+ 11	N+ 12	N+ 15	N+ 16	N+ 18	N+ 19	N+ 20	N+ 23	N+ 24
D1	7	-	28	31	-	-	35	-	39	-	43	-	-	47	-	51	-
D2	7	26	29	32	-	-	36	-	40	-	44	-	-	48	-	-	-
D3	7	27	30	33	-	-	37	-	41	-	45	-	-	49	-	-	-
D4	7	-	34	-	38	-	-	42	-	46	-	50	-	-	54	57	-
D5	3	-	52	55	-	58	-	-	-	-	-	-	-	-	-	-	-
D6	3	-	53	56	-	59	-	-	-	-	-	-	-	-	-	-	-
T-D1	7	-	26	-	30	-	-	34	-	38	-	42	-	-	46	-	50
T-D2	7	-	28	-	32	-	-	36	-	40	-	44	-	-	48	-	52

Note 1) Based on Radio Frequency Plan for Analog TV
Note 2) Channels in red are for DTTB implementation along THA-MLA border areas

Thank you