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"Understanding and testing of DMR standard"

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Presentation Title: Understanding and Testing DMR

Speaker: Roger Kane

DMR Overview

Digital **M**obile **R**adio (**DMR**) is a suite of standards developed by the European Telecommunications Standards Institute (ESTI) for narrow band land mobile communications

- **DMR Tier I:**
  direct mode communication without infra-structure
- **DMR Tier II:**
  direct mode and base station repeaters
  advanced voice features and integrated IP data services
- **DMR Tier III:**
  Trunking with a controller managing communication
  including simulcast and multicast

PARAMETER	VALUE
Channel spacing	12.5 K Hz
Modulation	4 – FSK
Modulation rate	9.6 kbps
Bits per symbol	2
Voice coder rate	DVSI AMBE+2™ (3.60 kbps)
Access format	2 - slot TDMA

DMR Specification

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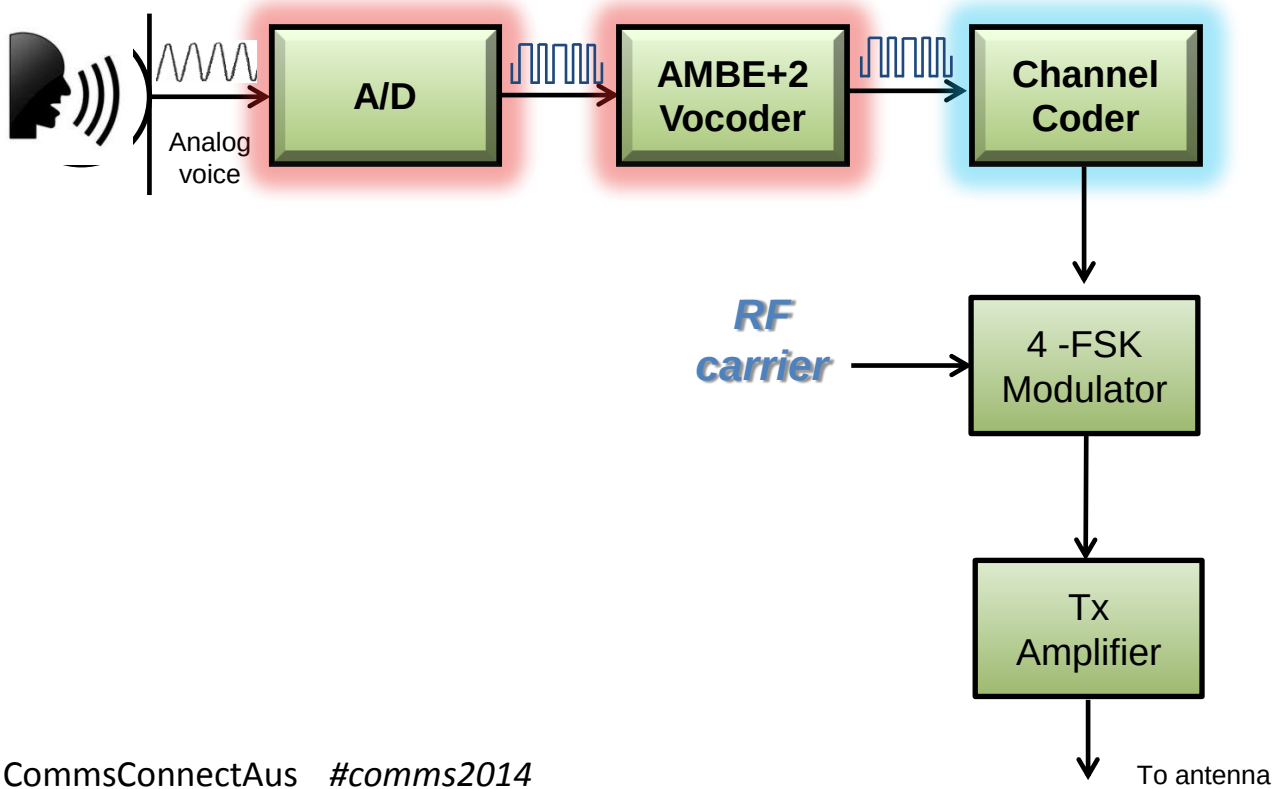
Digital Voice



DMR Technology - Modulation

DMR uses 4FSK (Four level Frequency Shift Key) derived from the standard FSK modulation

- 4FSK = four individual frequencies representing data values
- 2 data states “0” and “1” with 4 symbols transmitted so two bits per symbol
- Information bits are transmitted in pairs, each pair assigned to a frequency shift

Symbol	4FSK Deviation (Hz)
00	+648
01	+1944
10	-648
11	-1944

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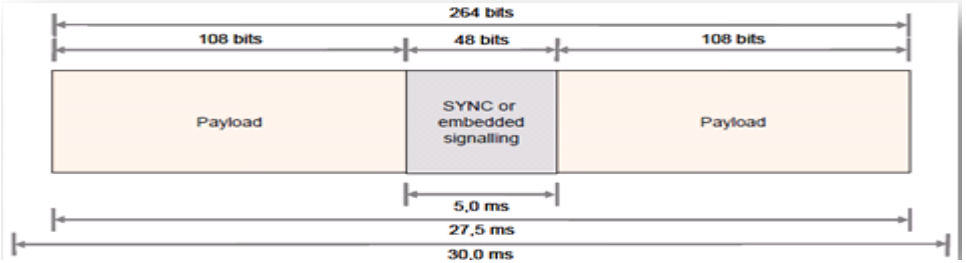
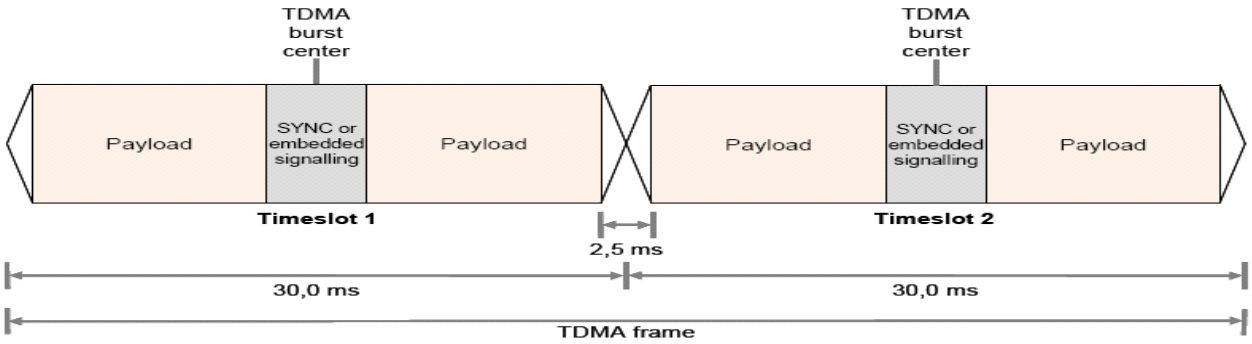
DMR Technology – Two Timeslots in TDMA

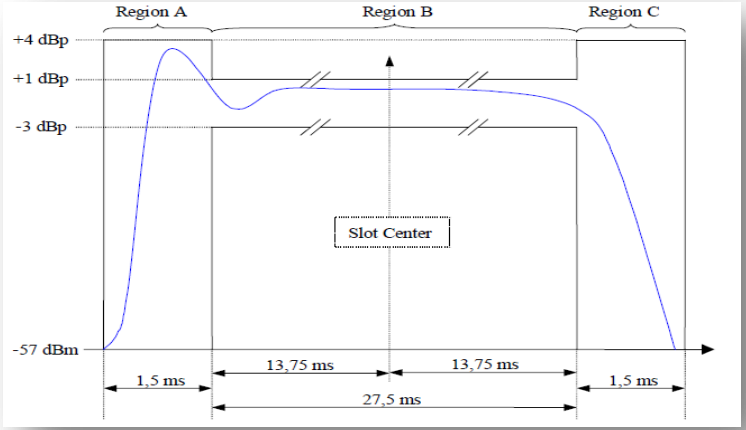
TDMA Slots – 30ms each



Slot 1 and Slot 2 – 60ms total



DMR Technology – Two Timeslots in TDMA



Normal Bursts Power Profile used for voice, data and control applications

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The Need for Testing

- Testing verifies system requirements and user needs are met
- Testing ensures ‘availability of service’ a paramount operational requirement
- Testing ensures interoperability of new equipment and evolving standards

FM test method Vs Digital DMR test method

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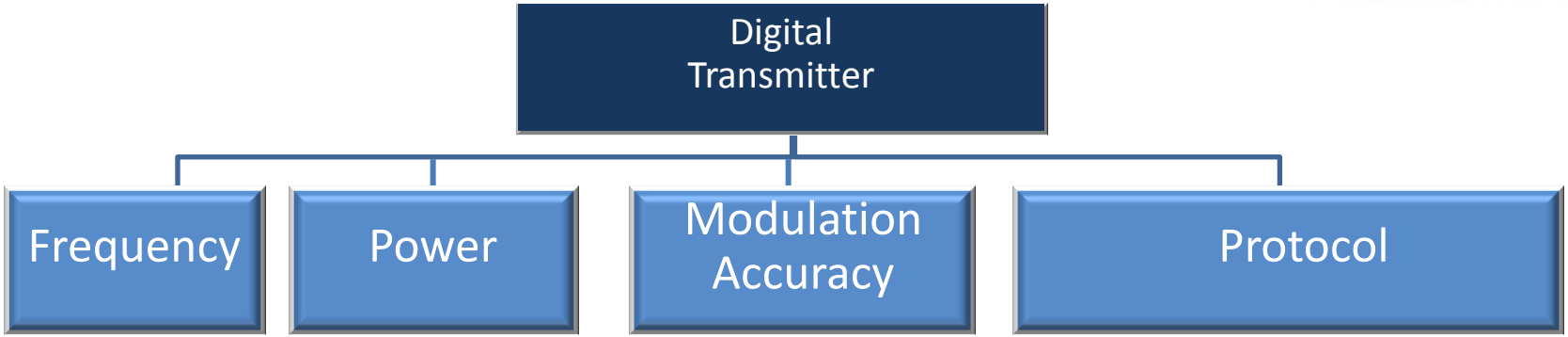

- similar to FM with constant – envelope modulation called 4FSK

- Burst power
  Timing of the signal

- FM uses deviation which does not work with 4FSK
- proper modulation analyser to perform
  (i) analysis synchronously with the symbol clock
  (ii) symbol clock errors calculation

- **Conventional**
  (i) analog analyser PL & DPL
  (ii) Colour Codes, Talk Goup,Call ID,
  (iii) full digital demodulation and error correction
- **Trunking**
  (i) radio will not "communicate" without a Control Channel
  (ii) complex messaging needed to get the radio "talking"
  (iii) interoperability with various OEM requires detailed analysis of messaging handling

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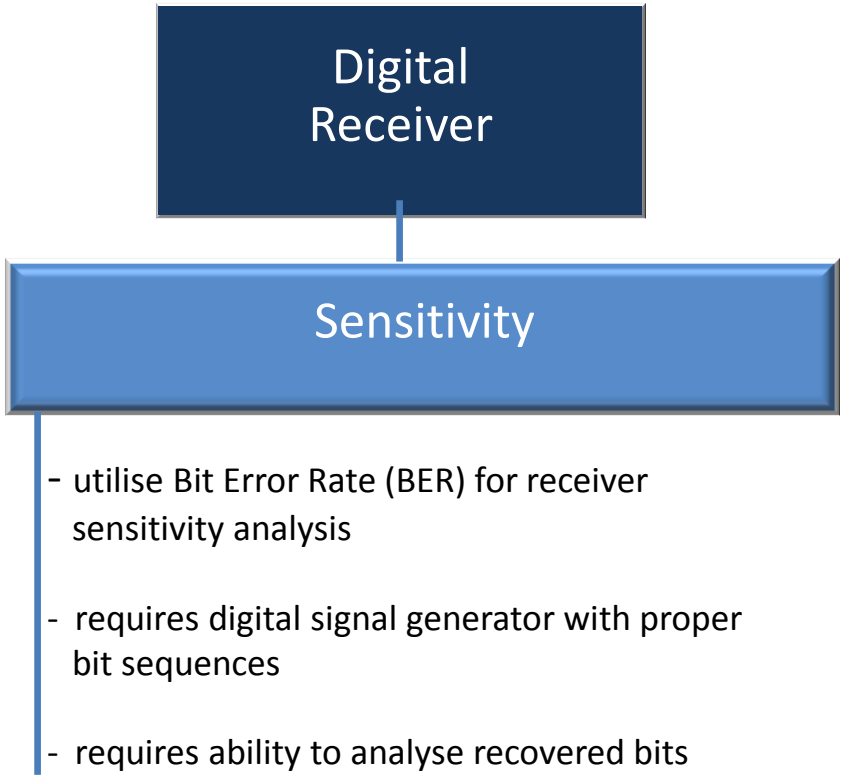
FM test method Vs Digital DMR test method



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Critical Tests

- MS Frequency Error: Max 2 ppm (50-600MHz); 1.5 ppm (>600MHz)
- FSK Error: Max Error < 5%
- Symbol Deviation Error: Max Error +/- 10% (2138Hz and 1749Hz)
- Magnitude Error: Max Error ≤ 1%
- Symbol Clock Error: Max Error ≤ 24 mHz
- Slot Power: Slot 1, Slot 2, and Slot dBr
- Rx BER: RF Level @ 5% Rx BER

Significant parameter measurement

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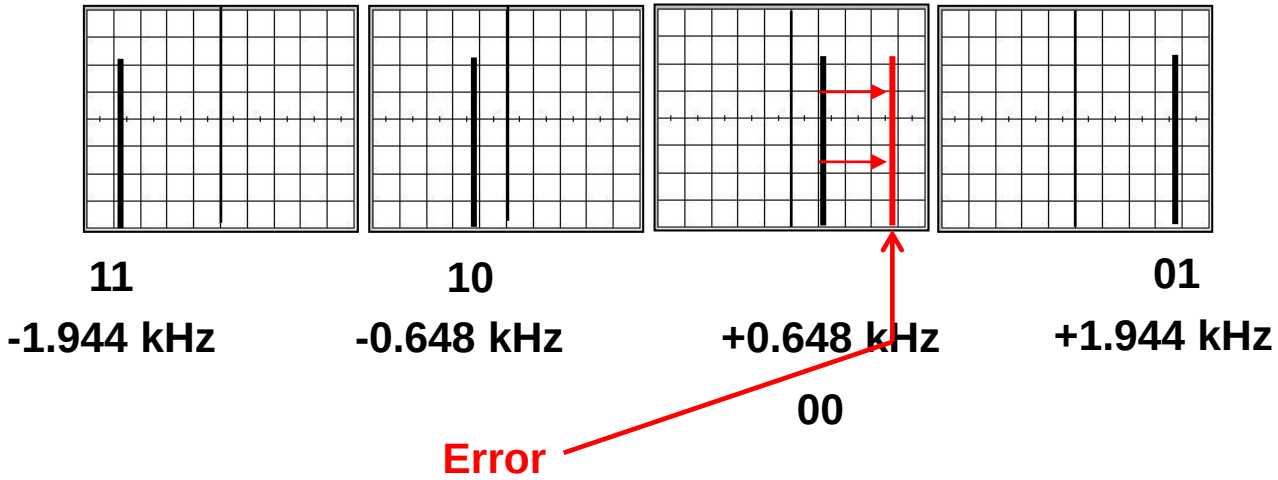
FSK error

What is this?

This measurement shows how closely the overall modulation is performing to the ideal



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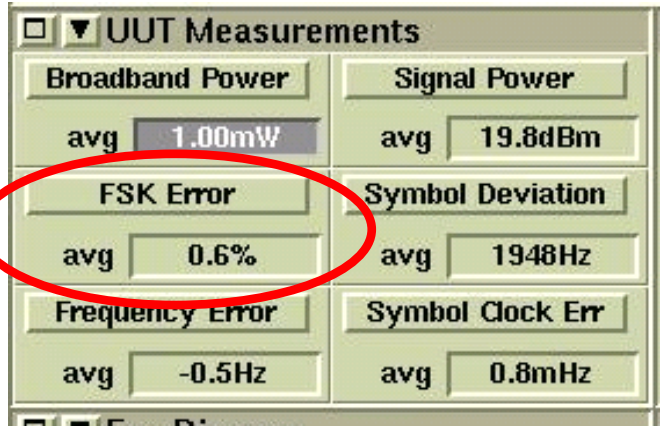
Significant parameter measurement

FSK error

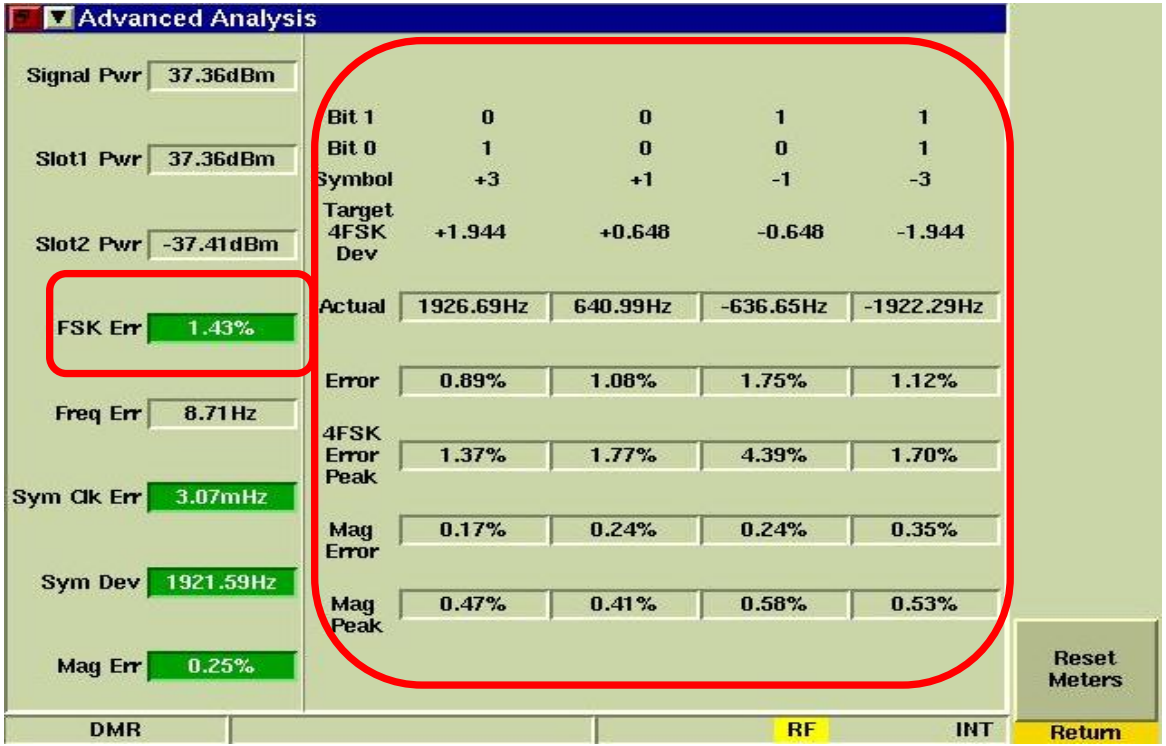
Why is this important?

FSK modulation measurements serve to check the signal quality requirements

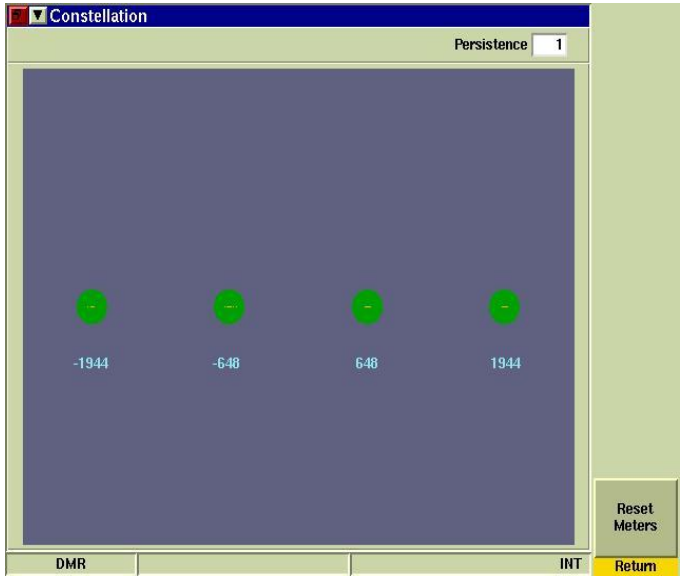
- to achieve coverage
- immunity to interference

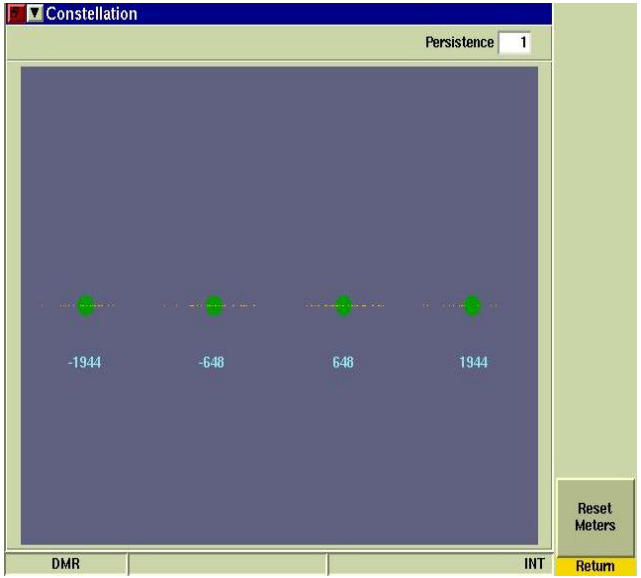


FSK error should **not exceed 5%**


Advanced Analysis
Signal Pwr 37.36dBm
Slot1 Pwr 37.36dBm
Slot2 Pwr -37.41dBm
FSK Err 1.43%
Freq Err 8.71Hz
Sym Clk Err 3.07mHz
Sym Dev 1921.59Hz
Mag Err 0.25%
Bit 1 0 0 1 1
Bit 0 1 0 0 1
Symbol +3 +1 -1 -3
Target 4FSK Dev +1.944 +0.648 -0.648 -1.944
Actual 1926.69Hz 640.99Hz -636.65Hz -1922.29Hz
Error 0.89% 1.08% 1.75% 1.12%
4FSK Error Peak 1.37% 1.77% 4.39% 1.70%
Mag Error 0.17% 0.24% 0.24% 0.35%
Mag Peak 0.47% 0.41% 0.58% 0.53%
Reset Meters
DMR
RF
INT
Return

Constellation Tile





- Four points represent the four deviation states
- The green plot fields indicate the expected location of the plot clusters
- A wide line extend outside of the circle if the FSK error is bad or the symbol deviation is too large or too small

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Significant parameter measurement

Another criterion for modulation Quality **SYMBOL CLOCK ERROR**

What is this?

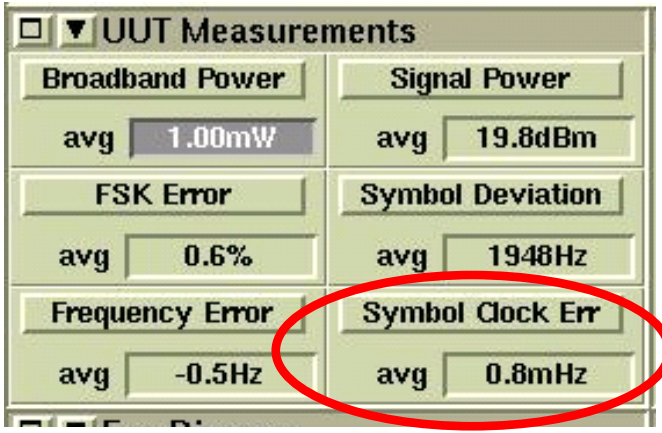
- Primary reference to ensure that the digital data is encoded and decoded correctly

Why is this important?

- Errors in symbol clock can cause digital jitter
- Excessive symbol clock error causes problem to symbol deviation performance

How is this measured?

- Measures over one 30ms slot
- Measured should not exceed +/- 48 mHz



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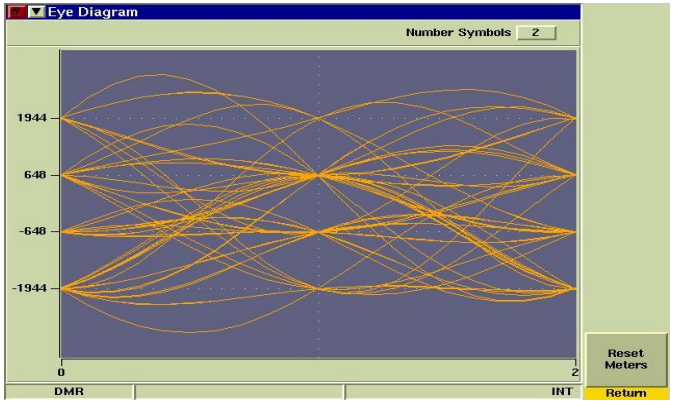
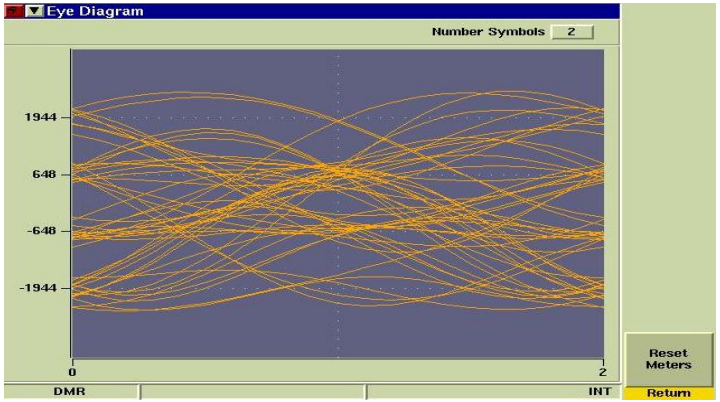
Eye Diagram Tile





- Graph of symbol deviation versus time
  - four horizontal dashed lines represent deviations at symbol point
  - the vertical dashed line and the start and stop of the graph are locations at which the graph goes through a symbol point
  - a good signal lines should cross precisely through the point at which the vertical and horizontal dashed lines meet
  - a wider or narrower symbol deviation will the plot passing below and /or above the dashed lines

Burst– Power in TDMA

For the duration of the time slot:
- the Tx Power must remain constant

- rise and fall times must be quick enough to not to interfere with adjacent timeslots

Burst– Power in TDMA

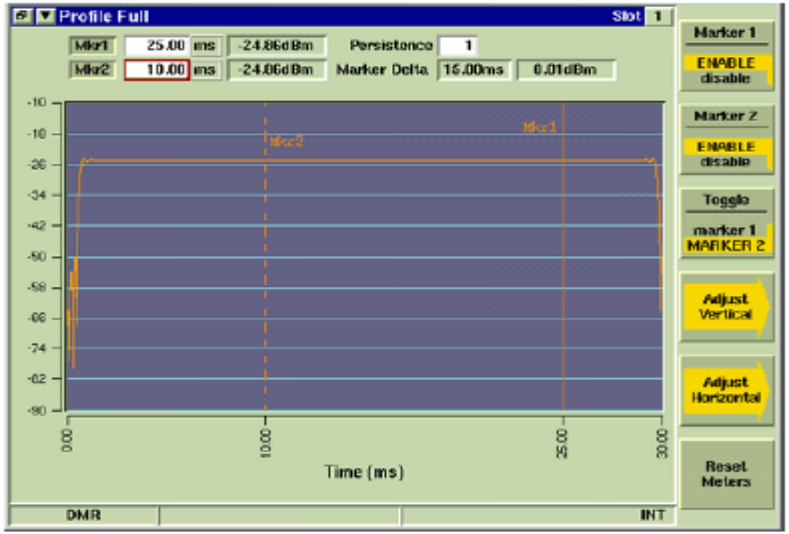


Fig. 2-14 Power Profile Full - Maximized View

The Power Profile Full Tile displays the **complete profile** of the signal's power reading over a period of time.

Burst– Power in TDMA

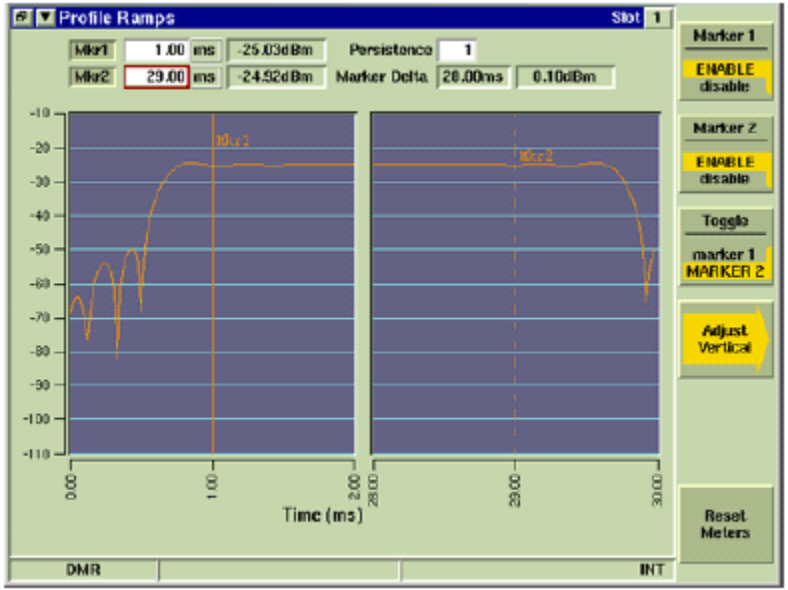


Fig. 2-17 Power Profile Ramps

The Profile Ramps Tile displays the ramp profile of the signal's power reading over one slot.

Receiver Testing

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Test Patterns

– 1031	Digital 1kHz tone (1031 Hz) Receiver Sensitivity Test for 5%BER
– Sync	Repeater Testing
– CAL and SILENCE	Introduces 5% BER onto 1031 pattern
– Stored Speech	subjective receiver sensitivity test

Duplex Radio & Repeater Testing

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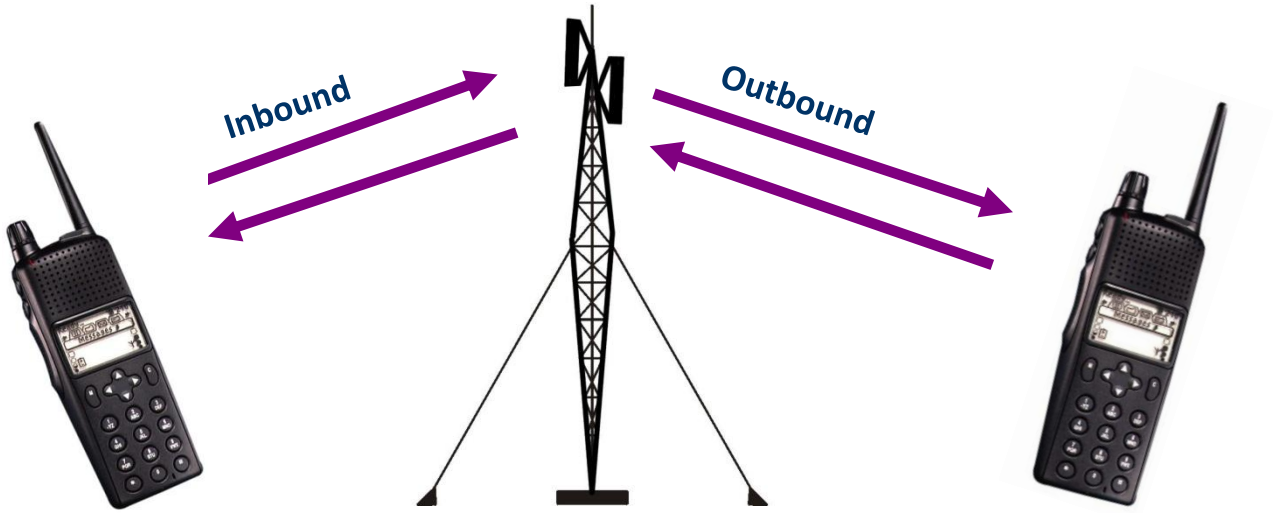
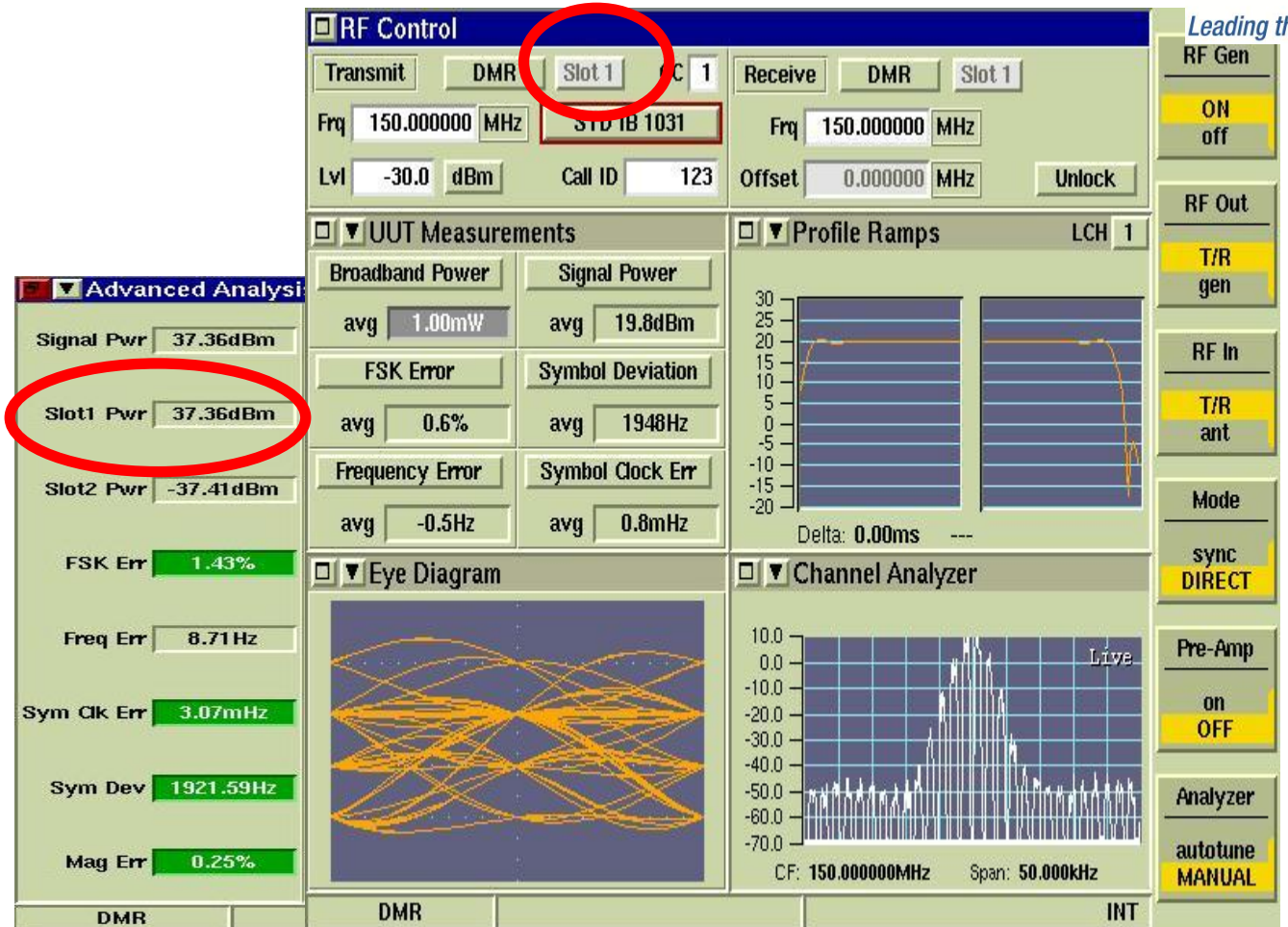
OB TSync Wake-Up Pattern for Duplex Radios

Special Test Signaling is Required!

Inbound:	Radio to Repeater	OB TSYNC Pattern (Wake-Up Burst)
Outbound:	Repeater to Radio	SYNC Pattern




RF Control
Transmit
DMR
Slot 1
Receive
DMR
Slot 1
Frq 150.000000 MHz
STD IB 1031
Frq 150.000000 MHz
Lvl -30.0 dBm
Call ID 123
Offset 0.000000 MHz
Unlock
RF Gen
ON
off
RF Out
T/R
gen
RF In
T/R
ant
Mode
sync
DIRECT
Pre-Amp
on
OFF
Analyzer
autotune
MANUAL
Advanced Analysis
Signal Pwr 37.36dBm
Slot1 Pwr 37.36dBm
Slot2 Pwr -37.41dBm
FSK Err 1.43%
Freq Err 8.71Hz
Sym Clk Err 3.07mHz
Sym Dev 1921.59Hz
Mag Err 0.25%
UUT Measurements
Broadband Power
avg 1.00mW
Signal Power
avg 19.8dBm
FSK Error
avg 0.6%
Symbol Deviation
avg 1948Hz
Frequency Error
avg -0.5Hz
Symbol Clock Err
avg 0.8mHz
Profile Ramps
LCH 1
30
25
20
15
10
5
0
-5
-10
-15
-20
Delta: 0.00ms ---
Eye Diagram
Channel Analyzer
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
Live
CF: 150.000000MHz
Span: 50.000kHz
DMR
DMR
INT

Testing Radios Protocol Side

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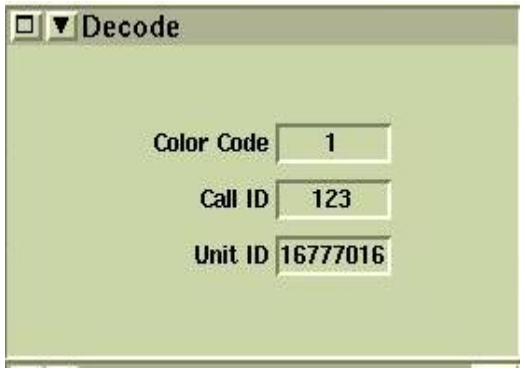
Color Code concept

Network access of DMR terminals are managed by a “colour code” instead of the traditional sub-audible tone

- To distinguish between adjacent and repeater stations with overlapping radio sites in order to detect co-channel interference

CALL ID

- This parameter is also referred to as the Destination ID or Group Address
- “ALL CALL” ID (16777215)



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