RF Circuit Design Concept

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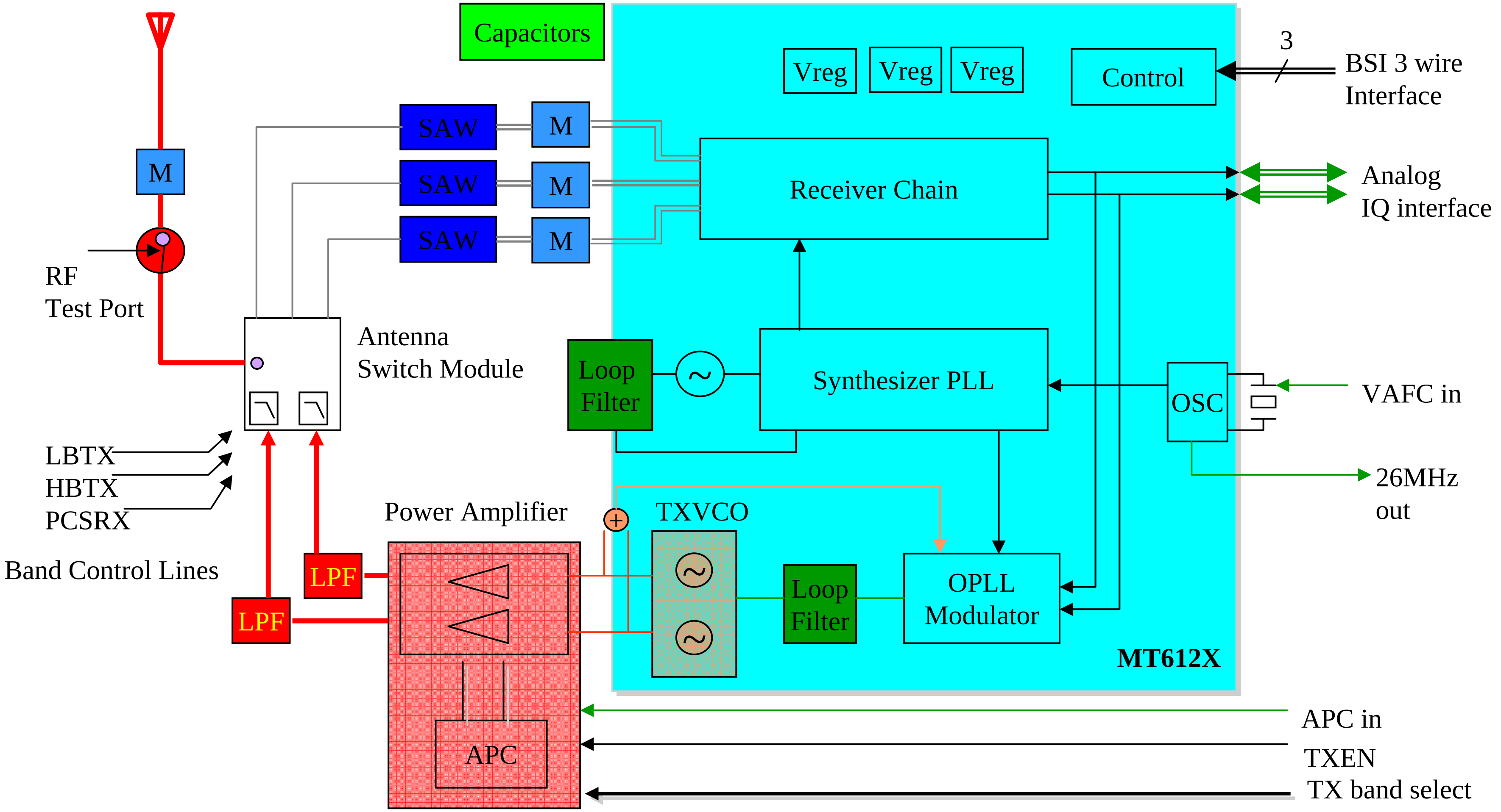
MediaTek
10 Sept, 2004

Outline

- RF Circuit Schematic
- RF Circuit Layout
- RF Circuit Debugging
- RF Specification
- RF Measurement
- RF Components of 2nd Source Qualification

Radio Transceiver Block Diagram



RF Circuit Schematic – MT612X

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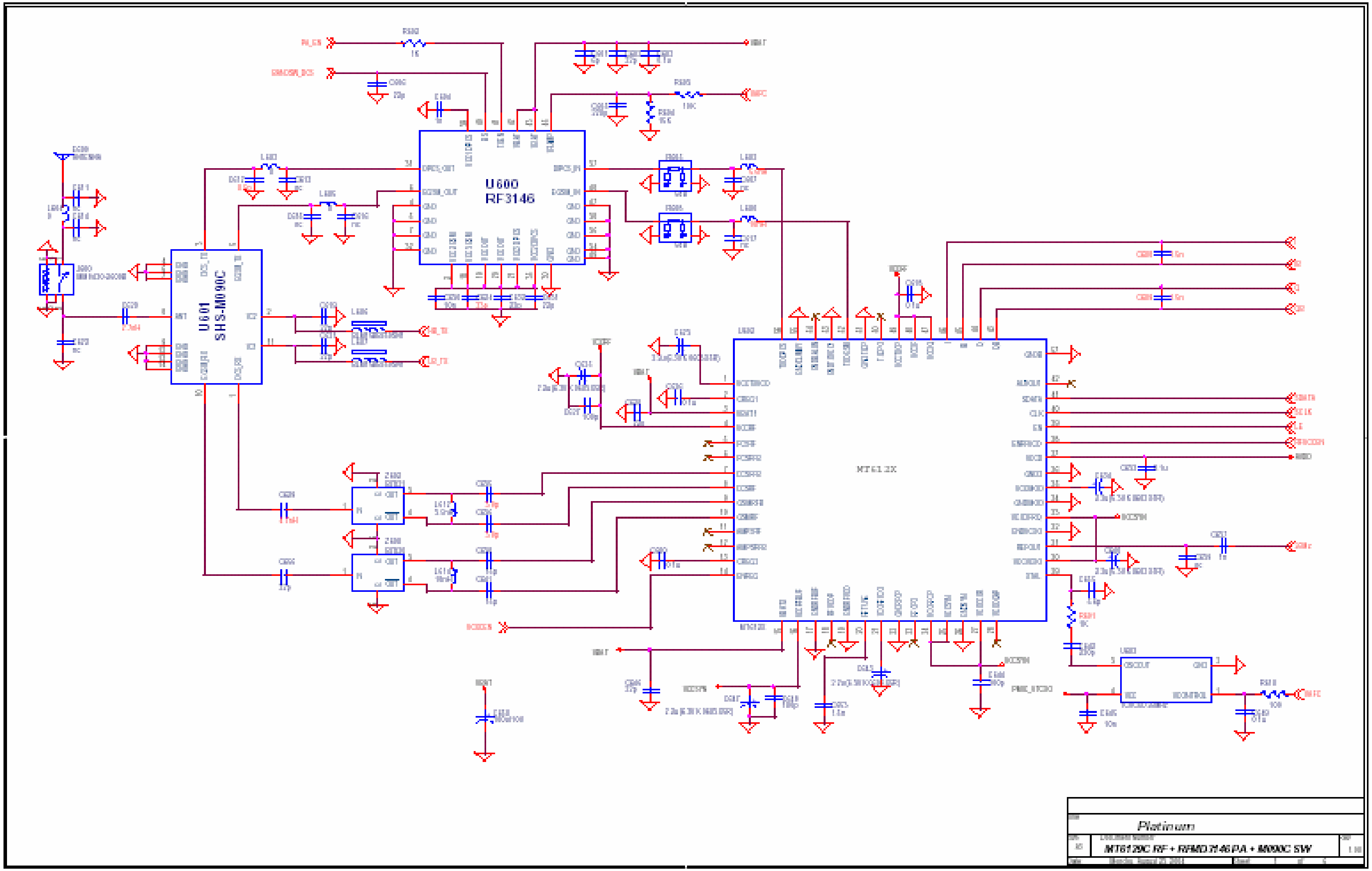
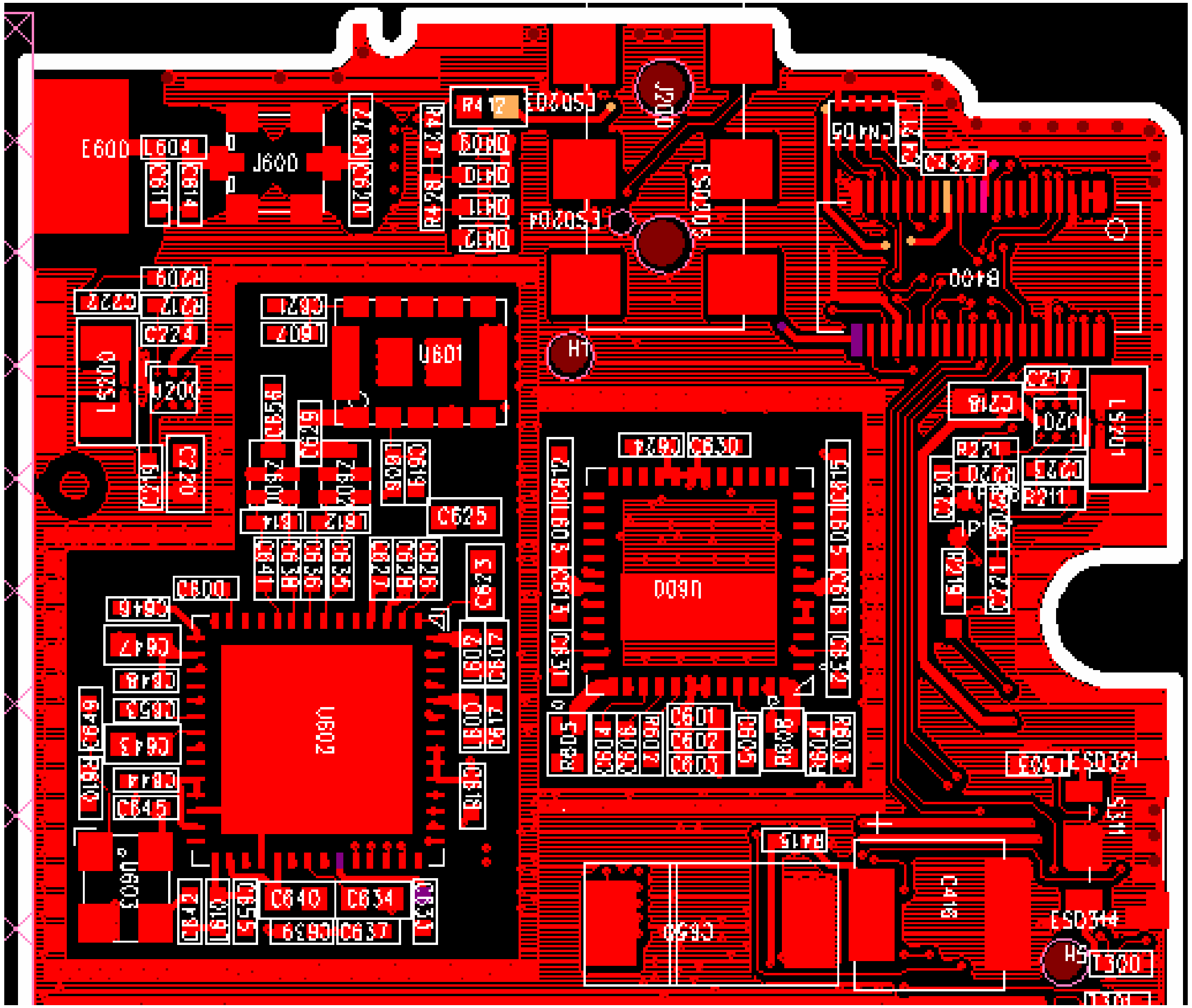
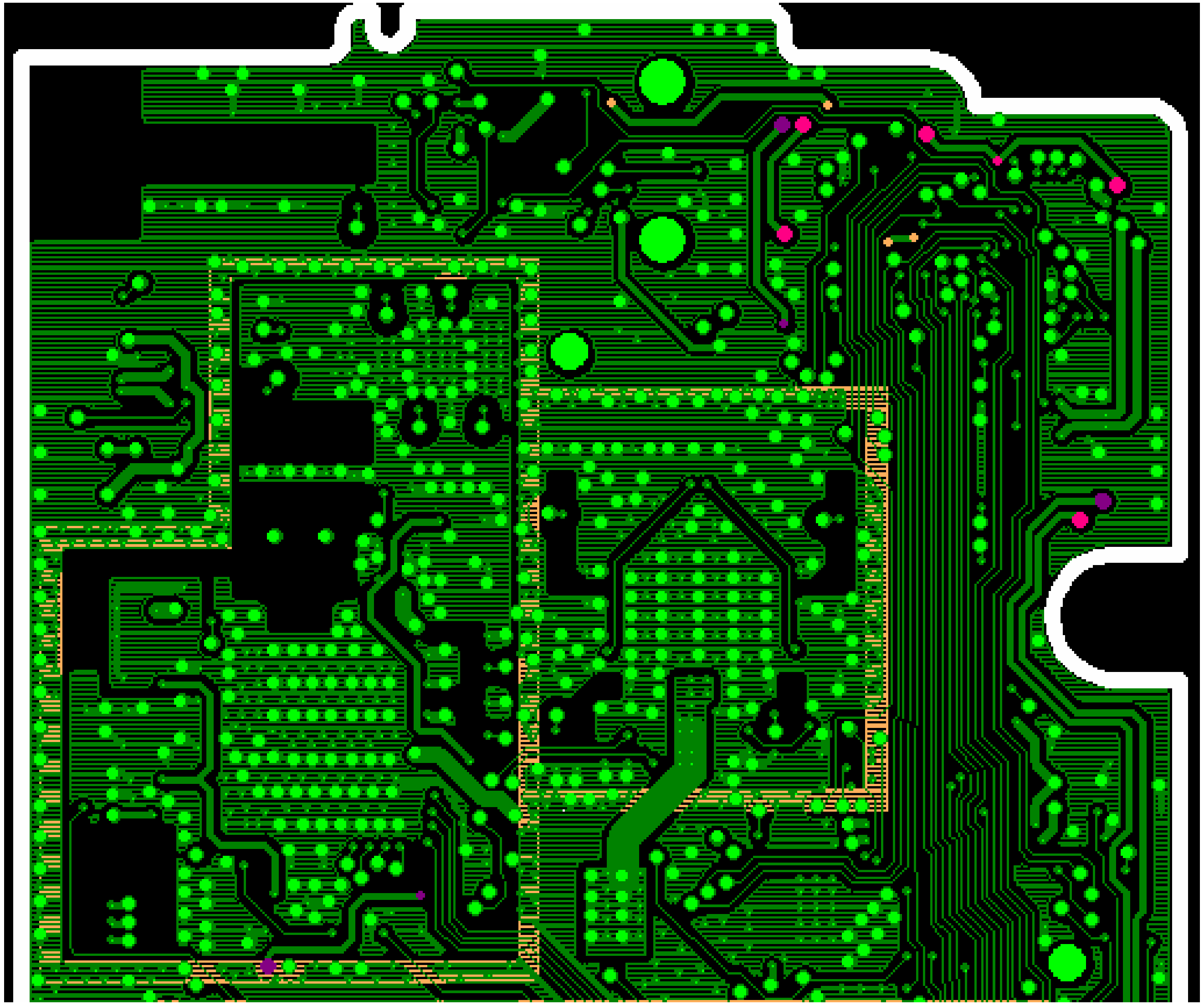


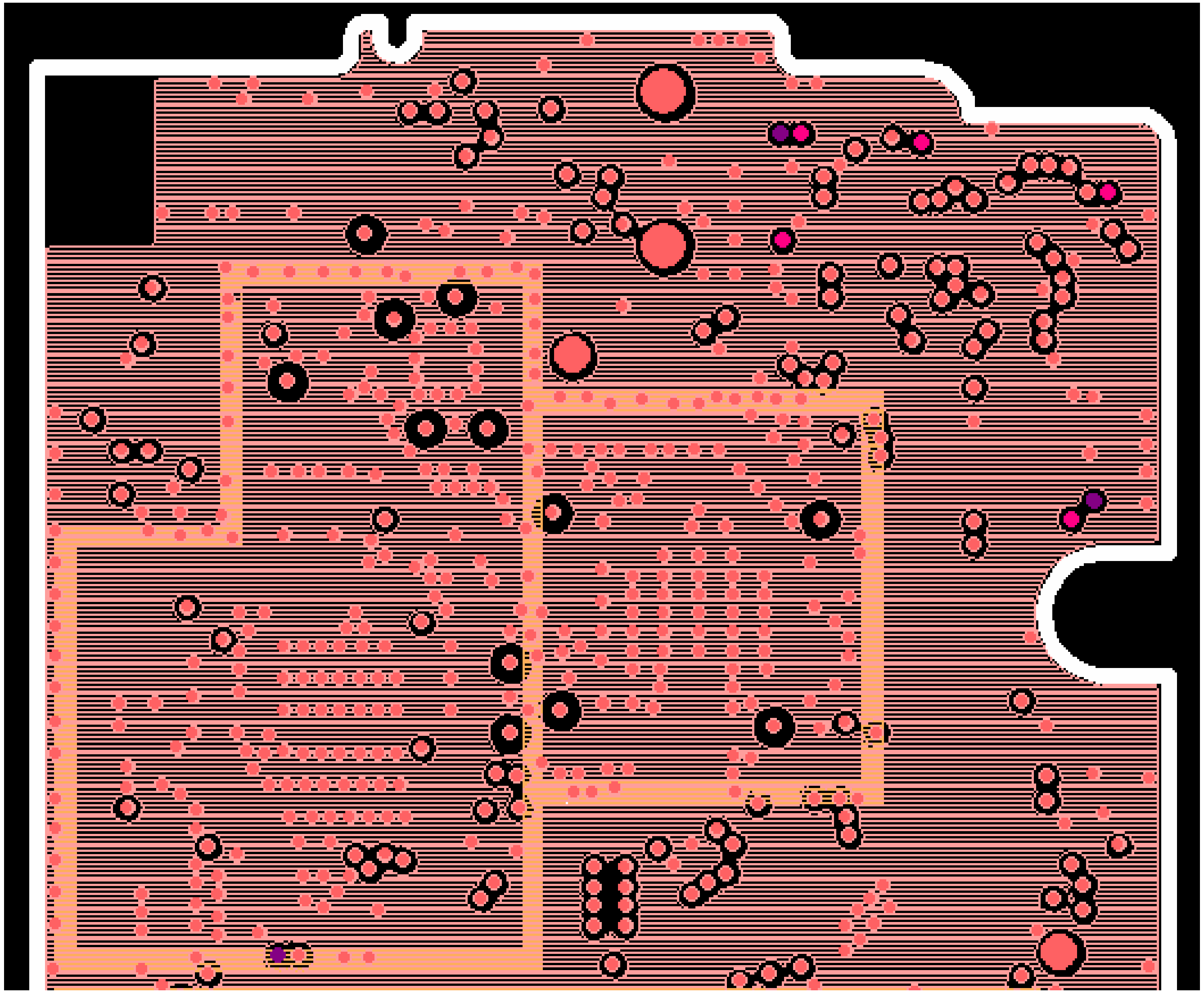
RF Circuit Layout_L1



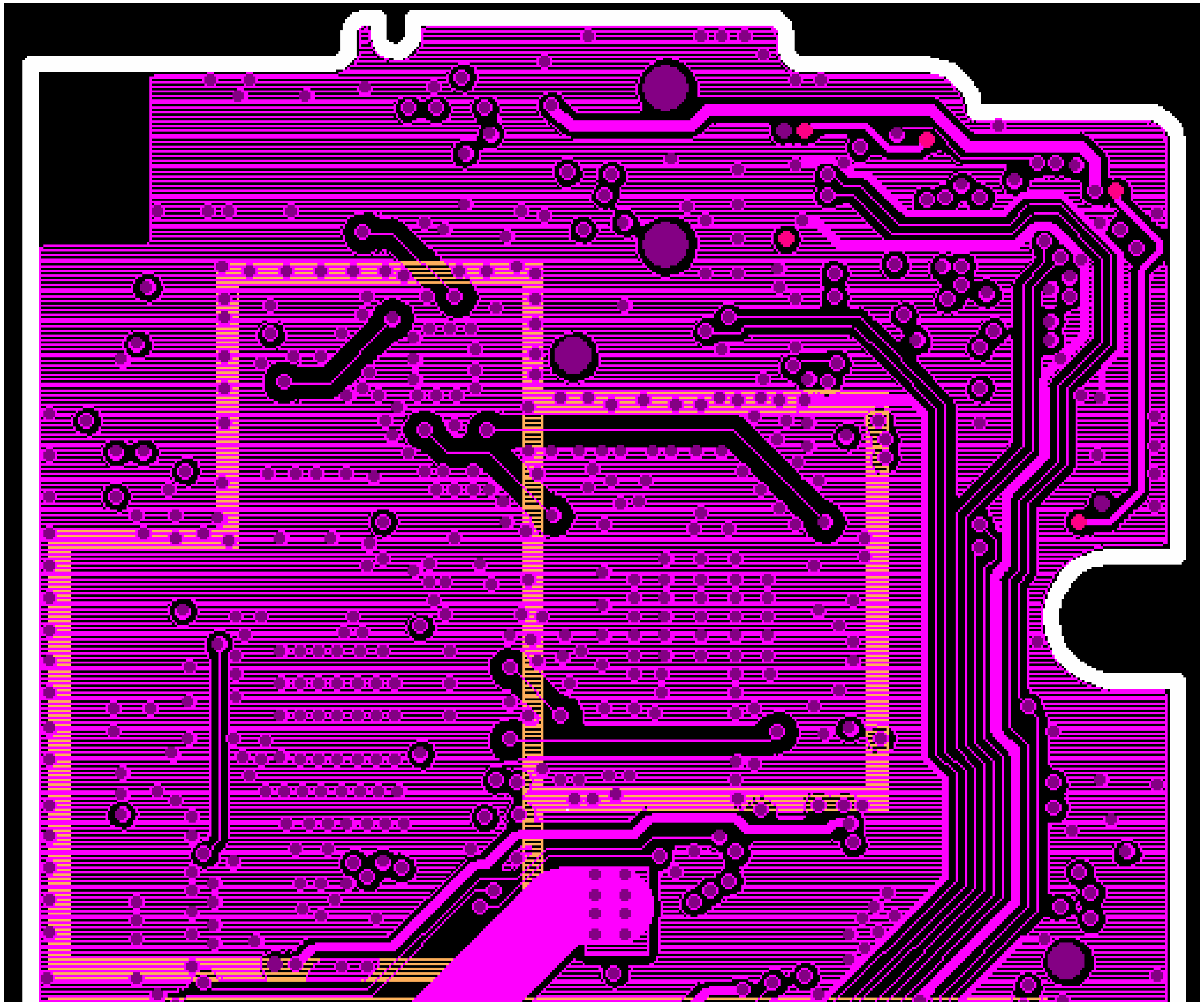
RF Circuit Layout_L2



RF Circuit Layout_L3

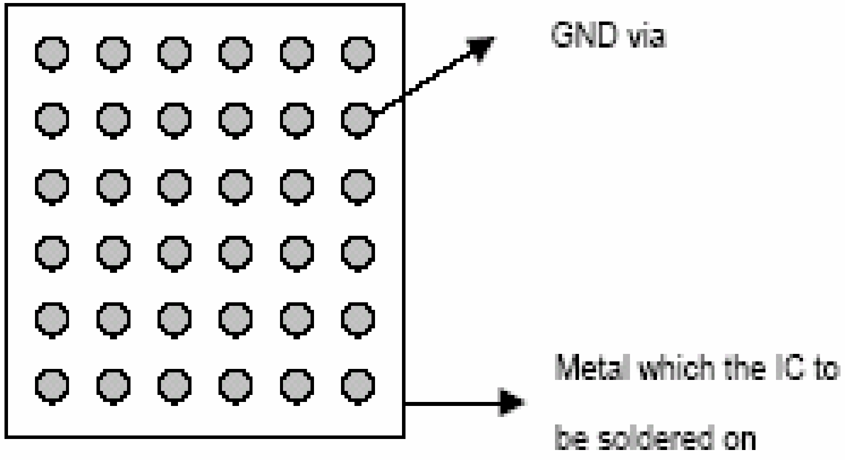


RF Circuit Layout_l4

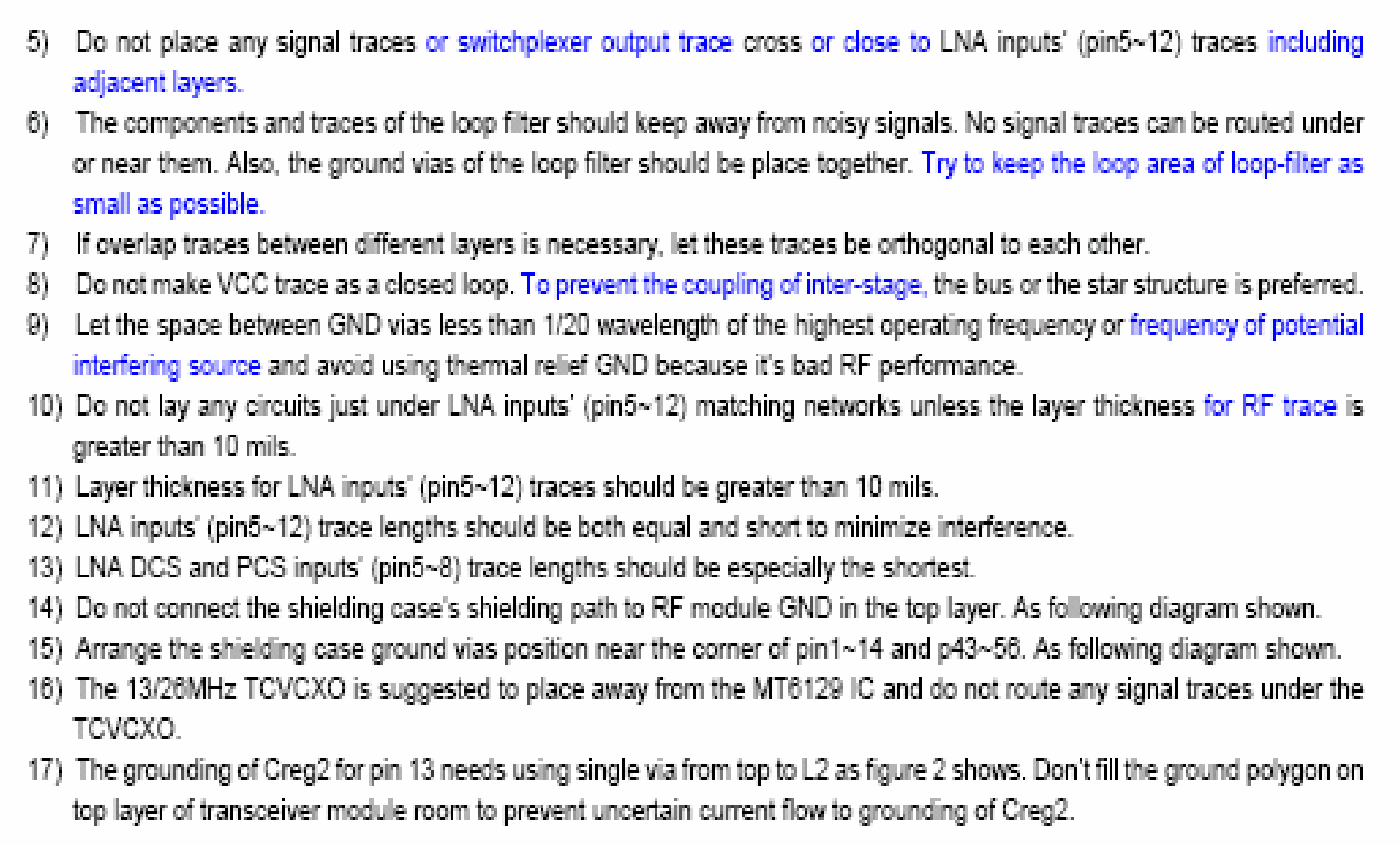


Transceiver IC Layout Guide - 1

1) Keep a sufficient distance between the RF signal trace and nearby vias. The distance should be larger than two widths of the RF signal.
2) Differential signals such as LNA input and IQ signals should have the same trace length from the IC to the matching component or the connector.
3) All ground pins should directly connect to a well-defined ground plane, and small value bypass capacitors must put as close as possible to the power supply pins.
4) The ground pad under IC should fill with ground vias as many as possible.

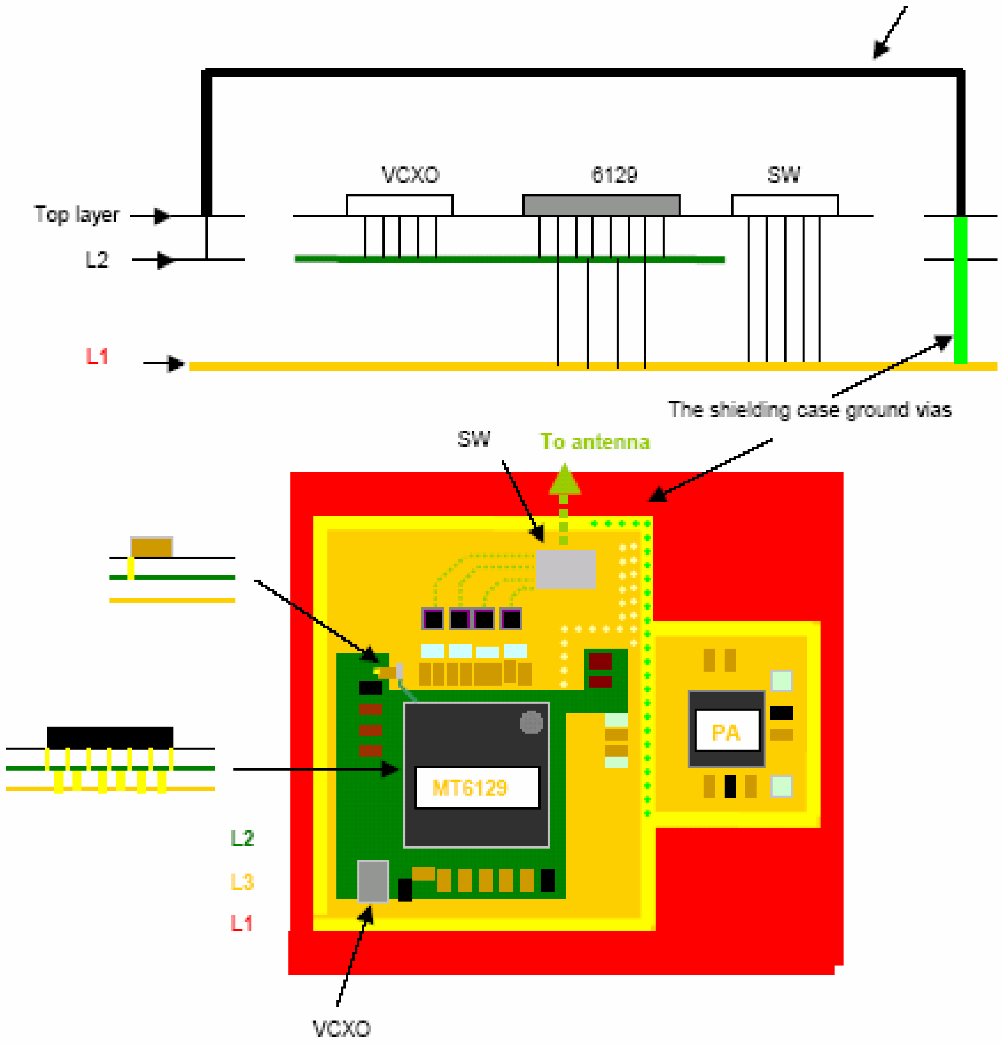


Transceiver IC Layout Guide - 2



5) Do not place any signal traces or switchplexer output trace cross or close to LNA inputs' (pin5~12) traces including adjacent layers.
6) The components and traces of the loop filter should keep away from noisy signals. No signal traces can be routed under or near them. Also, the ground vias of the loop filter should be place together. Try to keep the loop area of loop-filter as small as possible.
7) If overlap traces between different layers is necessary, let these traces be orthogonal to each other.
8) Do not make VCC trace as a closed loop. To prevent the coupling of inter-stage, the bus or the star structure is preferred.
9) Let the space between GND vias less than 1/20 wavelength of the highest operating frequency or frequency of potential interfering source and avoid using thermal relief GND because it's bad RF performance.
10) Do not lay any circuits just under LNA inputs' (pin5~12) matching networks unless the layer thickness for RF trace is greater than 10 mils.
11) Layer thickness for LNA inputs' (pin5~12) traces should be greater than 10 mils.
12) LNA inputs' (pin5~12) trace lengths should be both equal and short to minimize interference.
13) LNA DCS and PCS inputs' (pin5~8) trace lengths should be especially the shortest.
14) Do not connect the shielding case's shielding path to RF module GND in the top layer. As following diagram shown.
15) Arrange the shielding case ground vias position near the corner of pin1~14 and p43~56. As following diagram shown.
16) The 13/26MHz TCVCXO is suggested to place away from the MT6129 IC and do not route any signal traces under the TCVCXO.
17) The grounding of Creg2 for pin 13 needs using single via from top to L2 as figure 2 shows. Don't fill the ground polygon on top layer of transceiver module room to prevent uncertain current flow to grounding of Creg2.

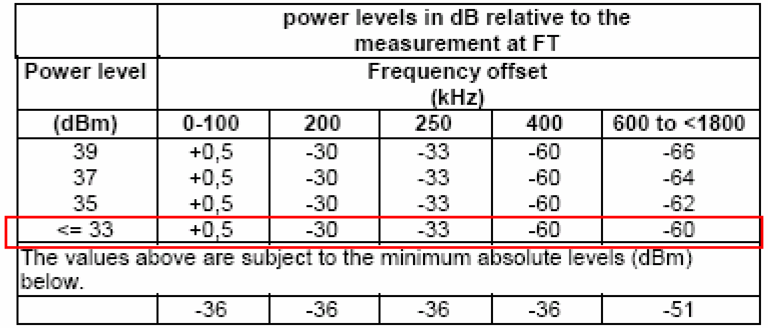
Transceiver IC Layout Guide - 3



RF Specification - 1

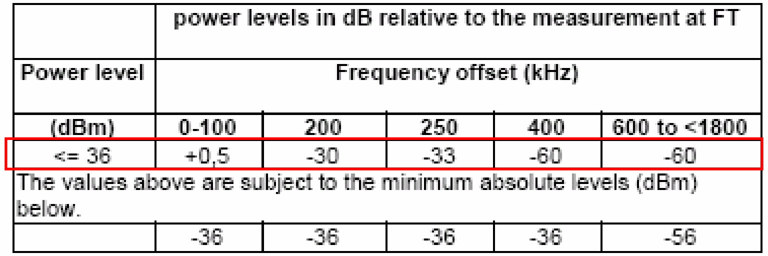
- **Tx Path**
  - Frequency Error : 0.1ppm
  - Phase Error
    - Peak Phase Error : 20 degree
    - RMS Phase Error : 5 degree
  - ORFS (Output Radio Frequency Spectrum)
    - 200KHz : -30dB
    - 250KHz : -33dB
    - 400KHz : -60dB
    - 600KHz~1.8MHz : -60dB

Table 13-6: GSM 400, GSM 700, GSM 850 and GSM 900 Spectrum due to modulation out to less than 1 800 kHz offset



Power level	power levels in dB relative to the measurement at FT				
	Frequency offset (kHz)				
(dBm)	0-100	200	250	400	600 to <1800
39	+0,5	-30	-33	-60	-66
37	+0,5	-30	-33	-60	-64
35	+0,5	-30	-33	-60	-62
<= 33	+0,5	-30	-33	-60	-60
The values above are subject to the minimum absolute levels (dBm) below.					
	-36	-36	-36	-36	-51

Table 13-7: DCS 1 800 Spectrum due to modulation out to less than 1 800 kHz offset

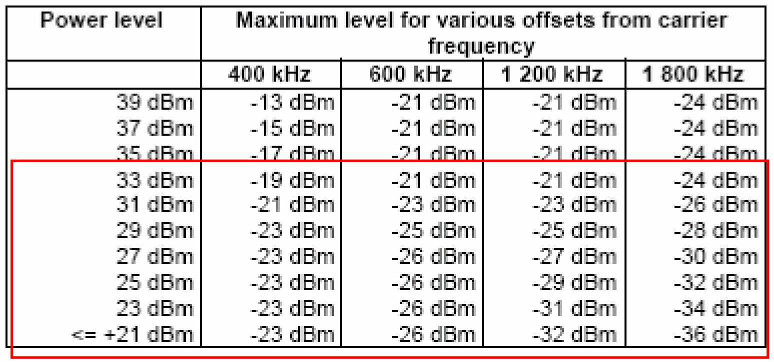


Power level	power levels in dB relative to the measurement at FT				
	Frequency offset (kHz)				
(dBm)	0-100	200	250	400	600 to <1800
<= 36	+0,5	-30	-33	-60	-60
The values above are subject to the minimum absolute levels (dBm) below.					
	-36	-36	-36	-36	-56

RF Specification - 2

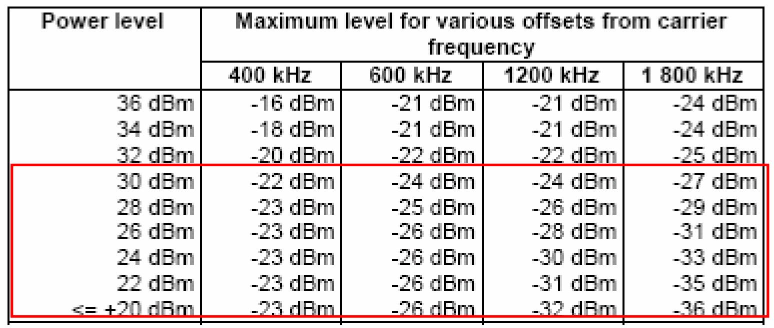
- Switching Spectrum
  - GSM PCL5
    - 400KHz : -19dBm
    - 600KHz : -21dBm
    - 1.2MHz : -21dBm
    - 1.8MHz : -24dBm
  - DCS PCL0
    - 400KHz : -22dBm
    - 600KHz : -24dBm
    - 1.2MHz : -24dBm
    - 1.8MHz : -27dBm

Table 13-11: GSM Spectrum due to switching transients



Power level	Maximum level for various offsets from carrier frequency			
	400 kHz	600 kHz	1 200 kHz	1 800 kHz
39 dBm	-13 dBm	-21 dBm	-21 dBm	-24 dBm
37 dBm	-15 dBm	-21 dBm	-21 dBm	-24 dBm
35 dBm	-17 dBm	-21 dBm	-21 dBm	-24 dBm
33 dBm	-19 dBm	-21 dBm	-21 dBm	-24 dBm
31 dBm	-21 dBm	-23 dBm	-23 dBm	-26 dBm
29 dBm	-23 dBm	-25 dBm	-25 dBm	-28 dBm
27 dBm	-23 dBm	-26 dBm	-27 dBm	-30 dBm
25 dBm	-23 dBm	-26 dBm	-29 dBm	-32 dBm
23 dBm	-23 dBm	-26 dBm	-31 dBm	-34 dBm
<= +21 dBm	-23 dBm	-26 dBm	-32 dBm	-36 dBm

Table 13-12: DCS 1 800 Spectrum due to switching transients

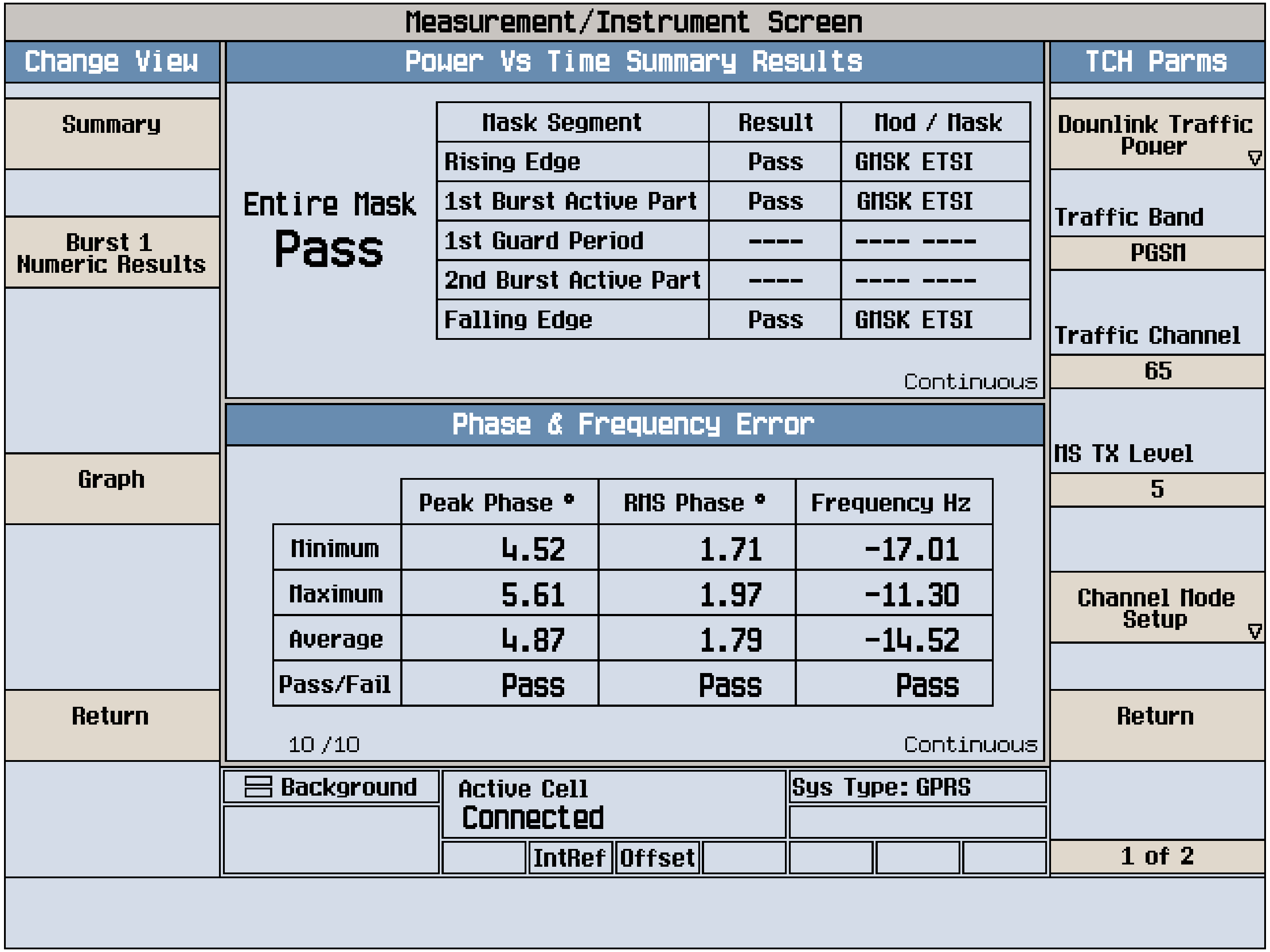


Power level	Maximum level for various offsets from carrier frequency			
	400 kHz	600 kHz	1200 kHz	1 800 kHz
36 dBm	-16 dBm	-21 dBm	-21 dBm	-24 dBm
34 dBm	-18 dBm	-21 dBm	-21 dBm	-24 dBm
32 dBm	-20 dBm	-22 dBm	-22 dBm	-25 dBm
30 dBm	-22 dBm	-24 dBm	-24 dBm	-27 dBm
28 dBm	-23 dBm	-25 dBm	-26 dBm	-29 dBm
26 dBm	-23 dBm	-26 dBm	-28 dBm	-31 dBm
24 dBm	-23 dBm	-26 dBm	-30 dBm	-33 dBm
22 dBm	-23 dBm	-26 dBm	-31 dBm	-35 dBm
<= +20 dBm	-23 dBm	-26 dBm	-32 dBm	-36 dBm

Rx Path

- Rx Sensitivity
  - -102dBm @ RBERII=2.4%

Measure within 8960 - Power vs Time(1)



Power Vs Time Summary Results

Entire Mask
Pass

Mask Segment	Result	Mod / Mask
Rising Edge	Pass	GMSK ETSI
1st Burst Active Part	Pass	GMSK ETSI
1st Guard Period	----	---- ----
2nd Burst Active Part	----	---- ----
Falling Edge	Pass	GMSK ETSI

Continuous

Phase & Frequency Error

	Peak Phase °	RMS Phase °	Frequency Hz
Minimum	4.52	1.71	-17.01
Maximum	5.61	1.97	-11.30
Average	4.87	1.79	-14.52
Pass/Fail	Pass	Pass	Pass

10 /10

Continuous

Traffic Band
PGSM

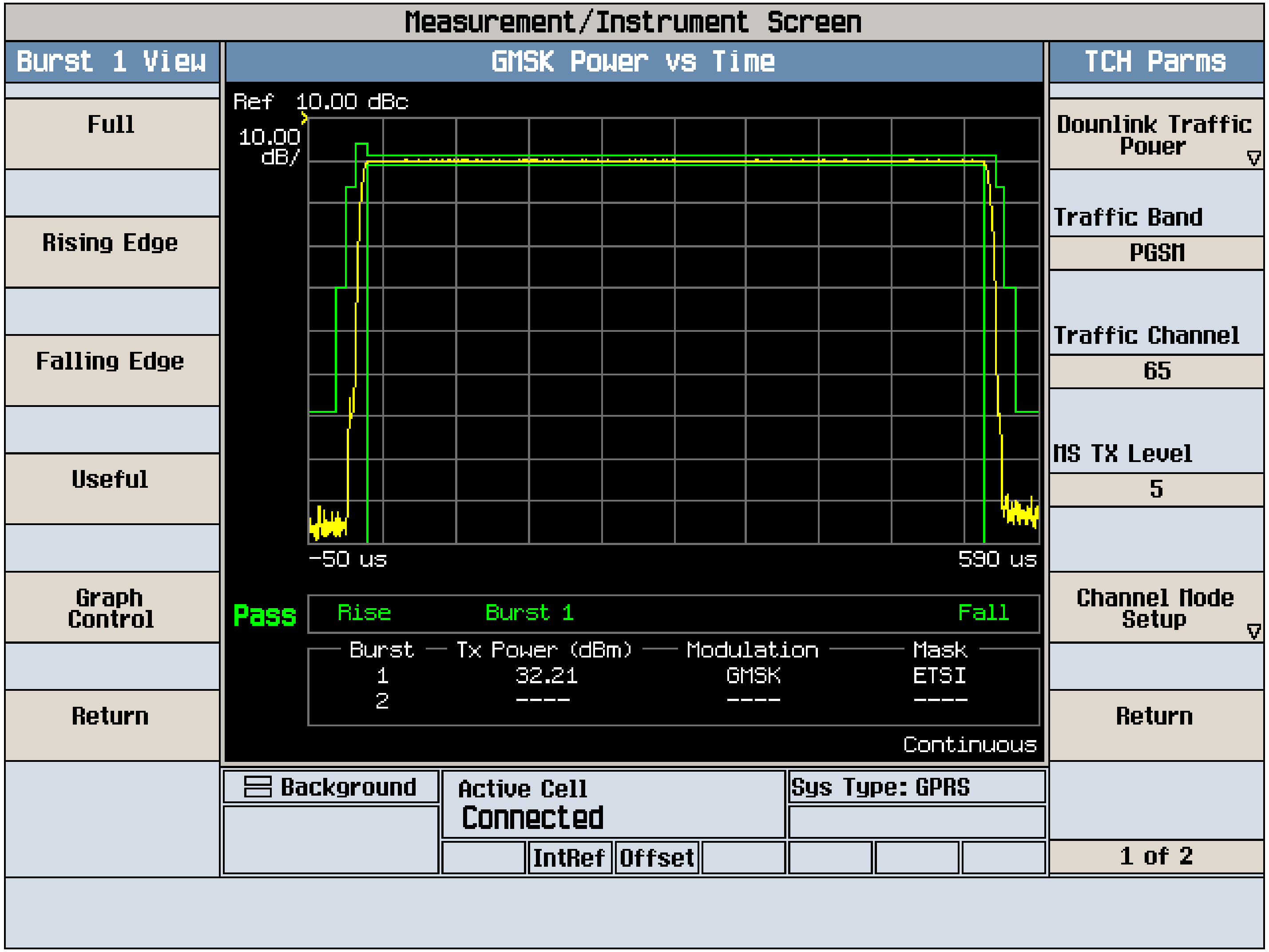
Traffic Channel
65

MS TX Level
5

Active Cell
Connected

Sys Type: GPRS

Measure within 8960 - Power vs Time(2)



Traffic Band: PGSM

Traffic Channel: 65

MS TX Level: 5

Pass

Rise | Burst 1 | Fall

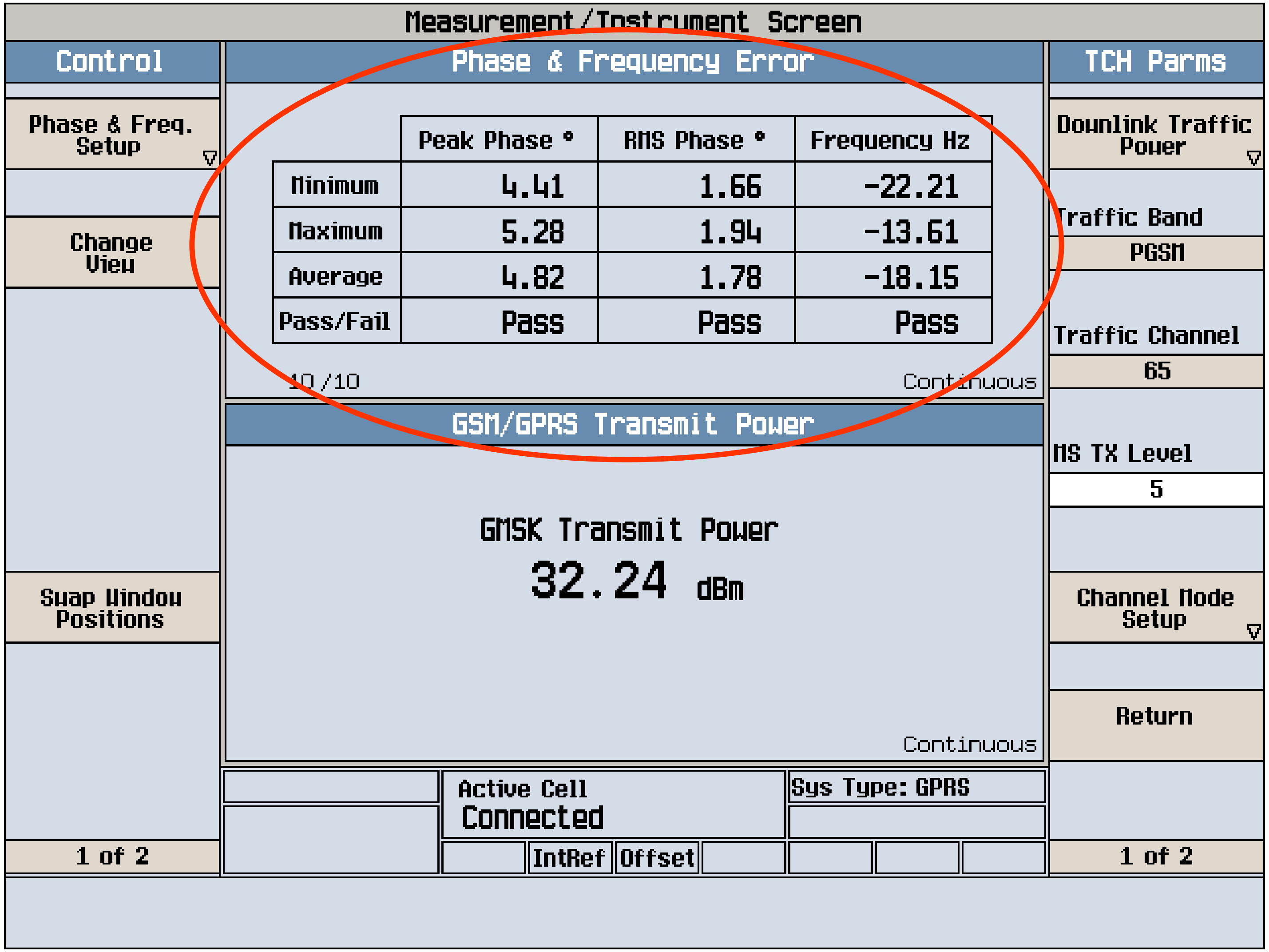
Burst	Tx Power (dBm)	Modulation	Mask
1	32.21	GMSK	ETSI
2	----	----	----

Continuous

Active Cell Connected

Sys Type: GPRS

Measure within 8960 - Phase & Freq. Error(1)



Phase & Frequency Error

	Peak Phase °	RMS Phase °	Frequency Hz
Minimum	4.41	1.66	-22.21
Maximum	5.28	1.94	-13.61
Average	4.82	1.78	-18.15
Pass/Fail	Pass	Pass	Pass

10/10 Continuous

GSM/GPRS Transmit Power

GMSK Transmit Power
32.24 dBm

Continuous

Traffic Band: PGSM

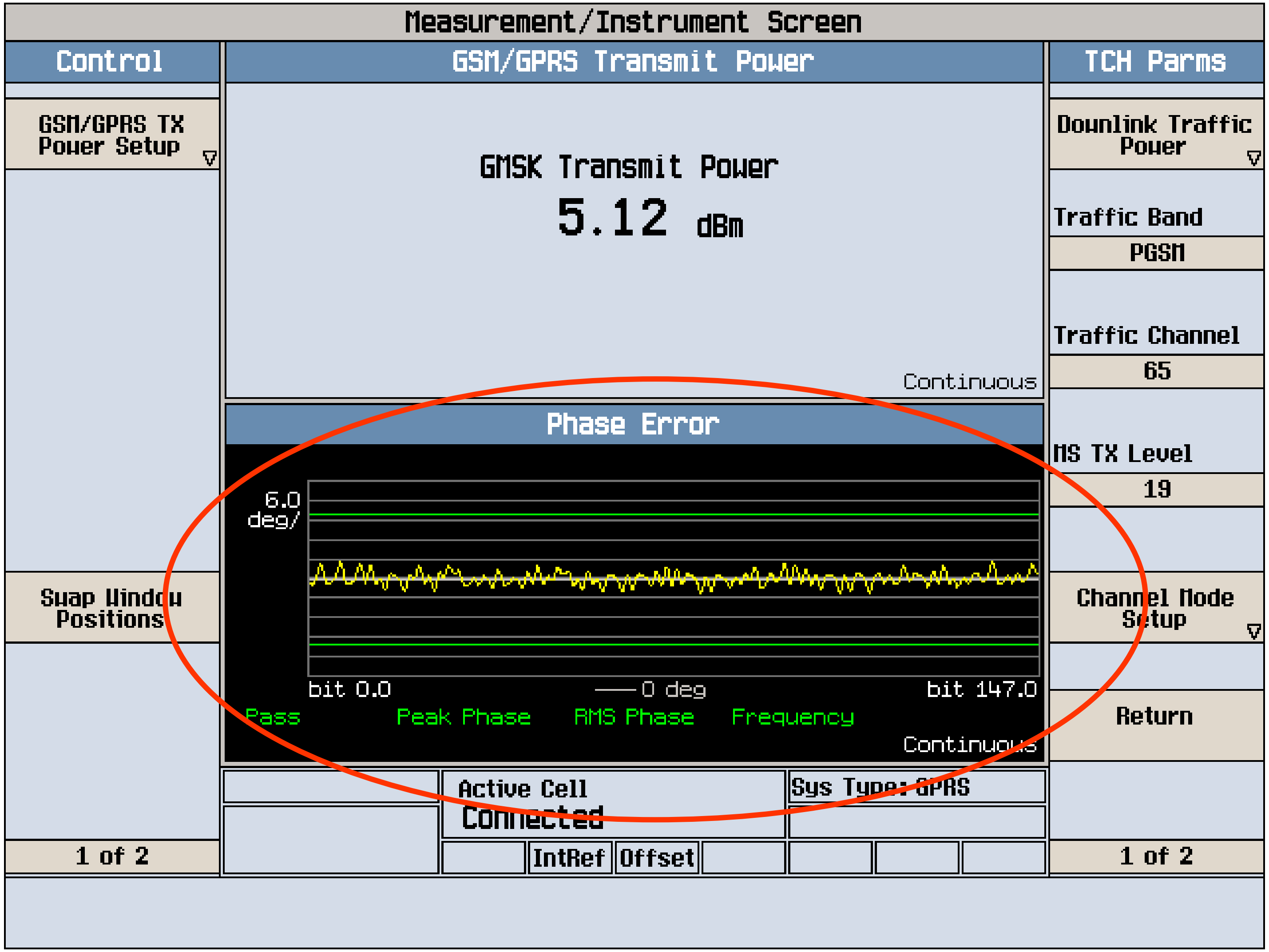
Traffic Channel: 65

MS TX Level: 5

Active Cell Connected

Sys Type: GPRS

Measure within 8960 - Phase & Freq. Error(2)



GMSK Transmit Power

5.12 dBm

Traffic Band: PGSM

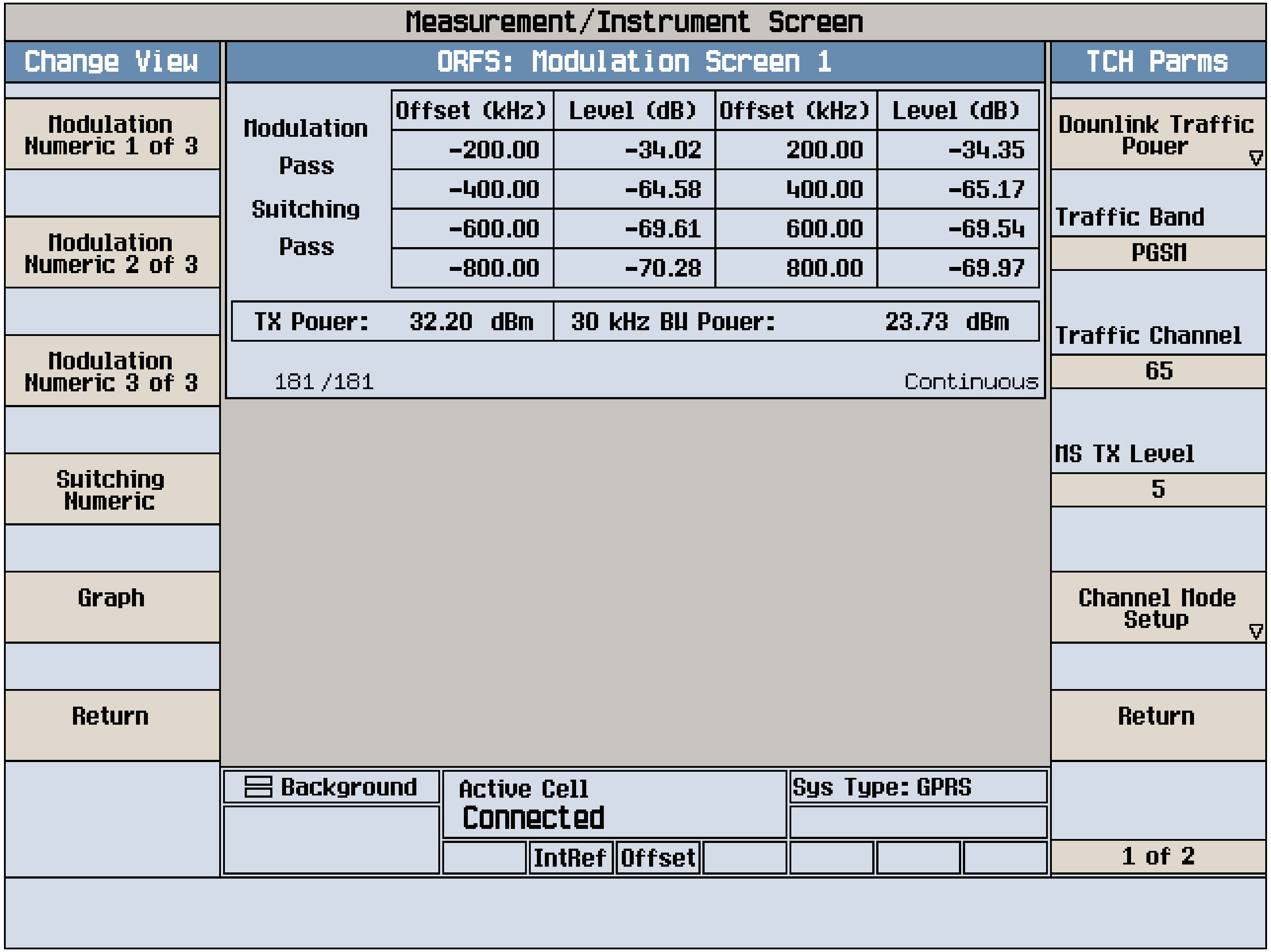
Traffic Channel: 65

MS TX Level: 19

Active Cell: Connected

Sys Type: GPRS

Measure within 8960 – ORFS



Measurement/Instrument Screen

ORFS: Modulation Screen 1

Modulation Pass

Switching Pass

Offset (kHz)	Level (dB)	Offset (kHz)	Level (dB)
-200.00	-34.02	200.00	-34.35
-400.00	-64.58	400.00	-65.17
-600.00	-69.61	600.00	-69.54
-800.00	-70.28	800.00	-69.97

TX Power: 32.20 dBm

30 kHz BW Power: 23.73 dBm

181/181

Continuous

Downlink Traffic Power

Traffic Band: PGSM

Traffic Channel: 65

MS TX Level: 5

Active Cell: Connected

Sys Type: GPRS

Measure within 8960 - Switching Spectrum

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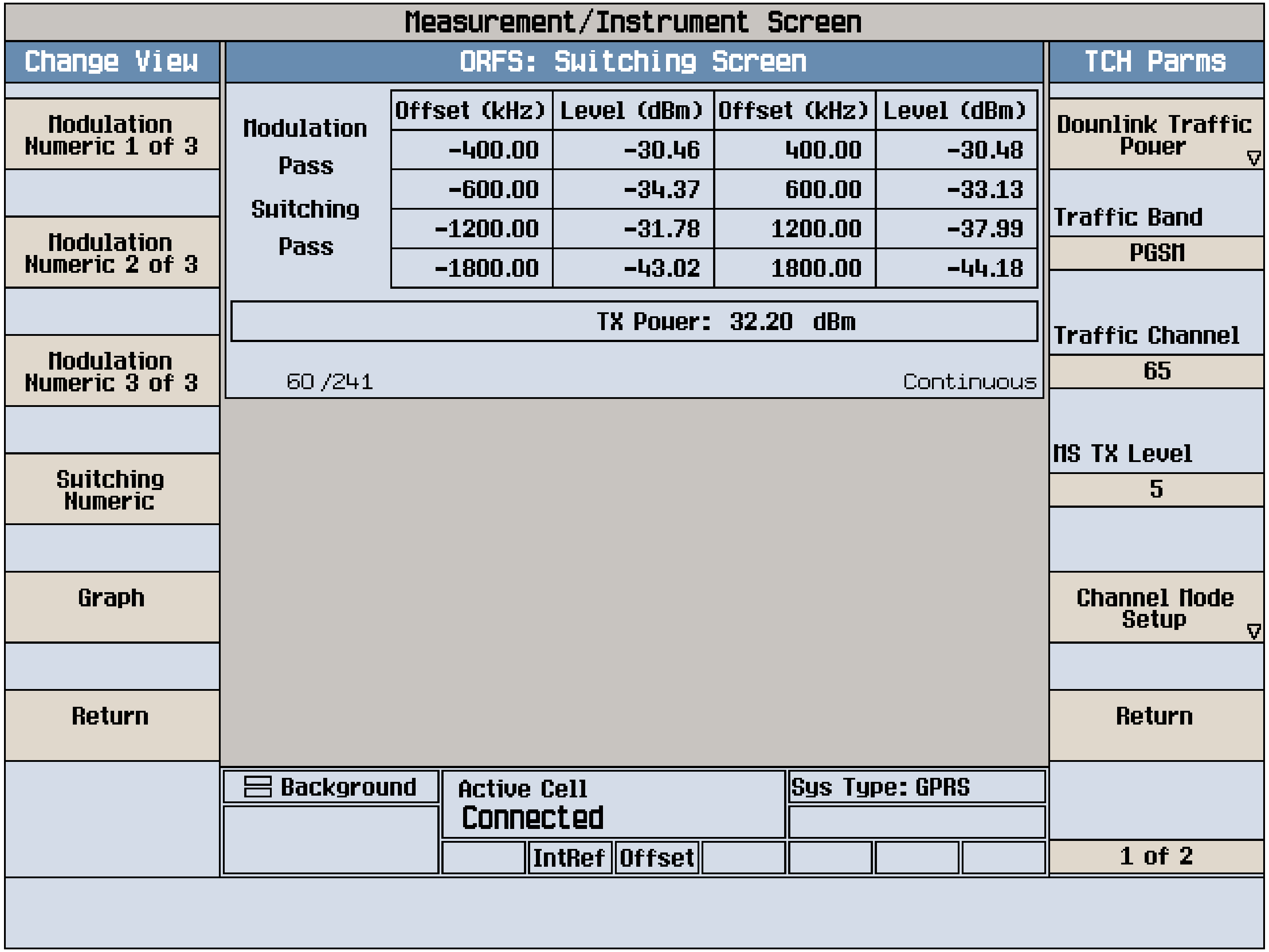


Modulation
Pass

Switching
Pass

Offset (kHz)	Level (dBm)	Offset (kHz)	Level (dBm)
-400.00	-30.46	400.00	-30.48
-600.00	-34.37	600.00	-33.13
-1200.00	-31.78	1200.00	-37.99
-1800.00	-43.02	1800.00	-44.18

TX Power: 32.20 dBm

60 /241 Continuous

Traffic Band
PGSM

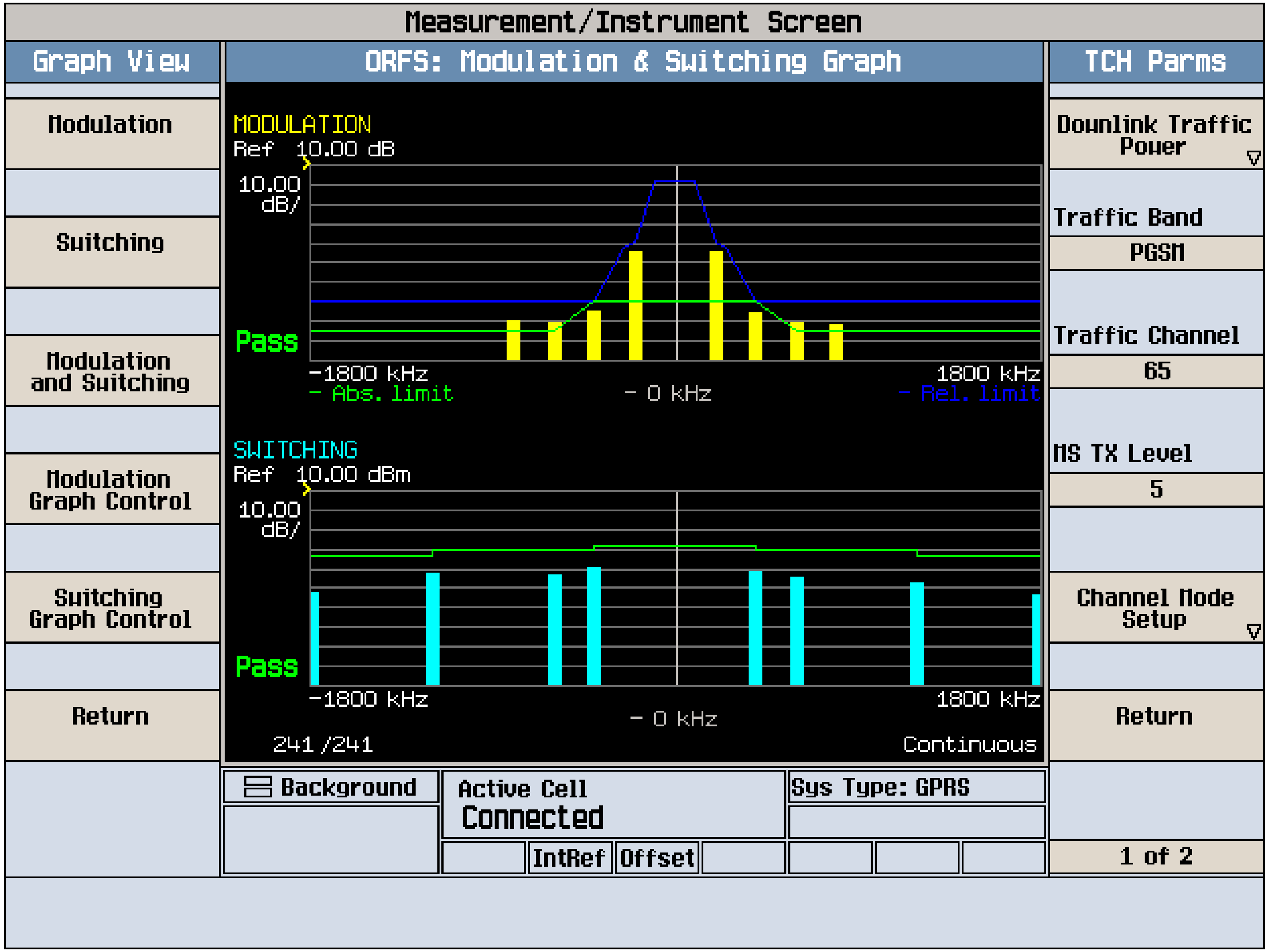
Traffic Channel
65

MS TX Level
5

Active Cell
Connected

Sys Type: GPRS

Measure within 8960 - ORFS & Switching



MODULATION Pass

SWITCHING Pass

241 /241

Continuous

Traffic Band
PGSM

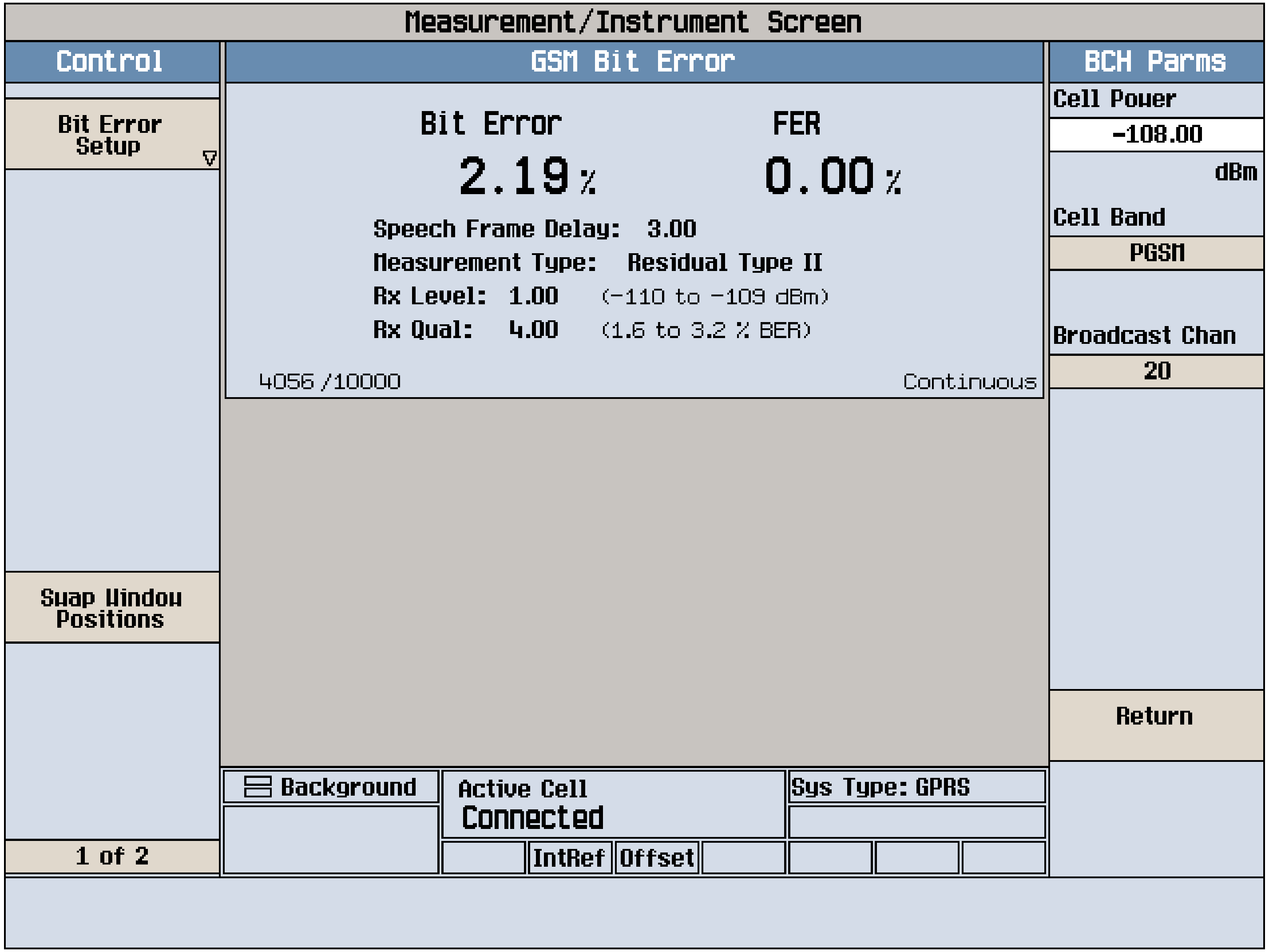
Traffic Channel
65

MS TX Level
5

Active Cell
Connected

Sys Type: GPRS

Measure within 8960 – Bit Error Rate



Bit Error 2.19 %

FER 0.00 %

Speech Frame Delay: 3.00

Measurement Type: Residual Type II

Rx Level: 1.00 (-110 to -109 dBm)

Rx Qual: 4.00 (1.6 to 3.2 % BER)

4056 /10000 Continuous

Cell Power -108.00 dBm

Cell Band PGSM

Broadcast Chan 20

Active Cell Connected

Sys Type: GPRS

RF 2^{nd} Source Component Qualification - 1

- **RF SAW**
  - Return Loss from Antenna (S11 parameter)
  - Rx Sensitivity
  - Attenuation Performance
  - Blocking Test
- **ASM (Antenna Switch Module)**
  - Rx Sensitivity
  - Tx Output Power
  - Tx Harmonic for High Order Term
  - Isolation

RF 2nd Source Component Qualification - 2

- **VCTCXO**
  - Frequency Error
  - Phase Error (Peak, RMS)
  - ORFS (200K, 400K, 800K, 1.8MHz)
  - In Extreme Condition
- **TXVCO**
  - Phase Error (Peak, RMS)
  - Power vs. Time Mask
  - Tx Output Power for each PCL
  - Harmonic
  - In Extreme Condition

RF Circuit Debugging - 1

- **AFC Fail**
  - Check VCTCXO circuit ok ?
    - 26MHz clock (input/output)?
    - VAFC controllable ?
  - Check Rx path ok ?
- **Path Loss Check Fail**
  - Check Rx path ok ?
    - ASM and SAW solder issue ?
    - LNA matching ?
    - Check LNA input impedance ?

RF Circuit Debugging - 2

APC Fail

- Check Tx path ok? Current value ?
  - PA and TXVCO solder issue ?
  - Attenuator SMT invert ?
  - Tx matching ?
  - VAPC controllable ?
  - Check TXVCO or PA output ?

MTK Anechoic Chamber

❖MTK anechoic chamber (7*4*3m)

➢Antenna & Wireless measurement

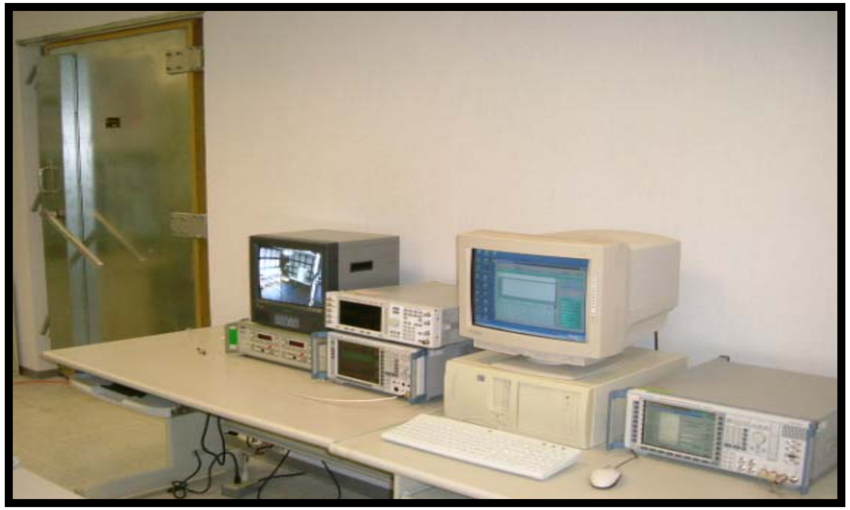
-provide suggestion for antenna and mechanical design in proto-type

-avoid EMI noise to degrade wireless sensitivity

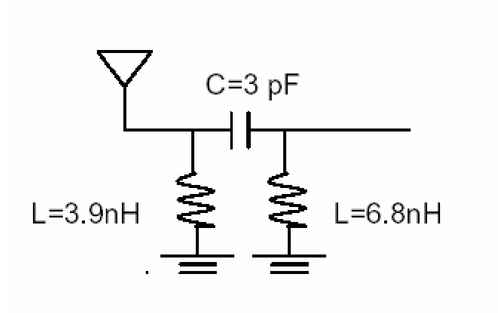
➢ Spurious & EMC pretest

-provide suggestion of layout design in proto-type

-provide radiated spurious and EMC solution

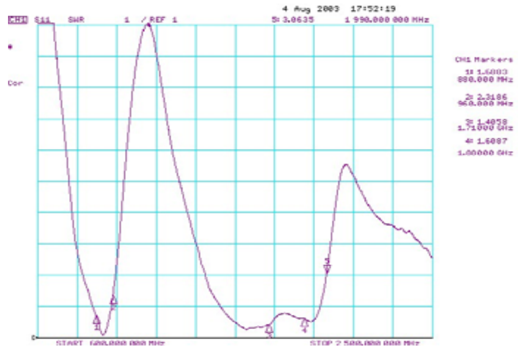


Antenna Test

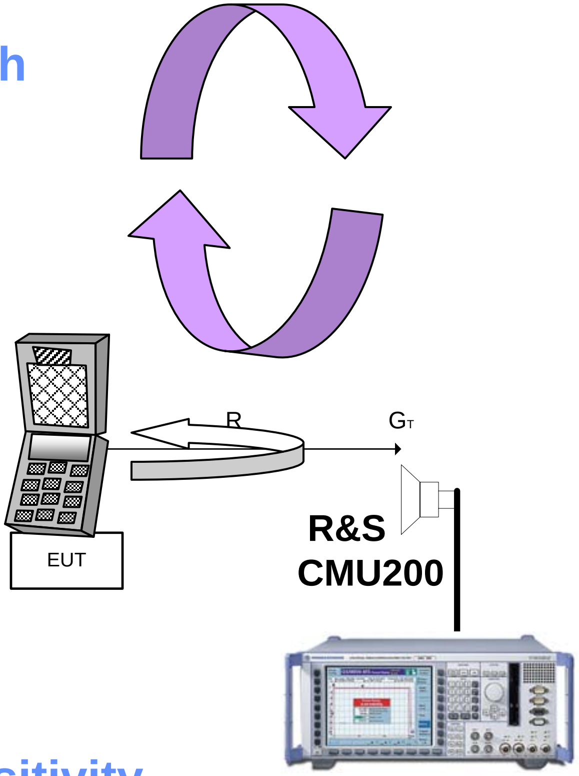


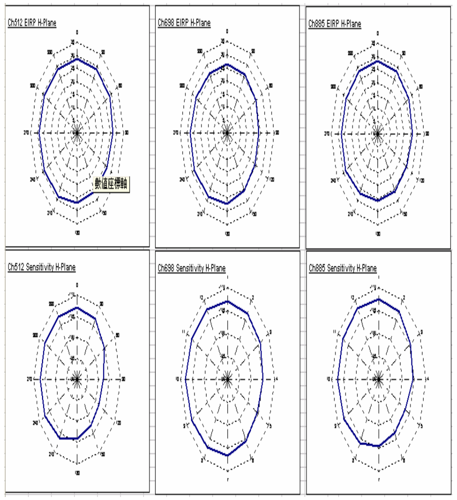
Tune antenna and match

Agilent 8753 VNA

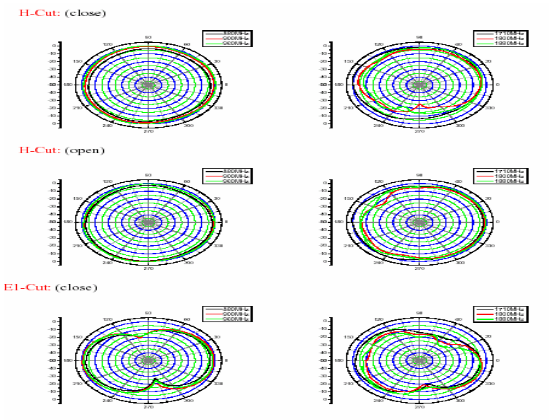


VSWR



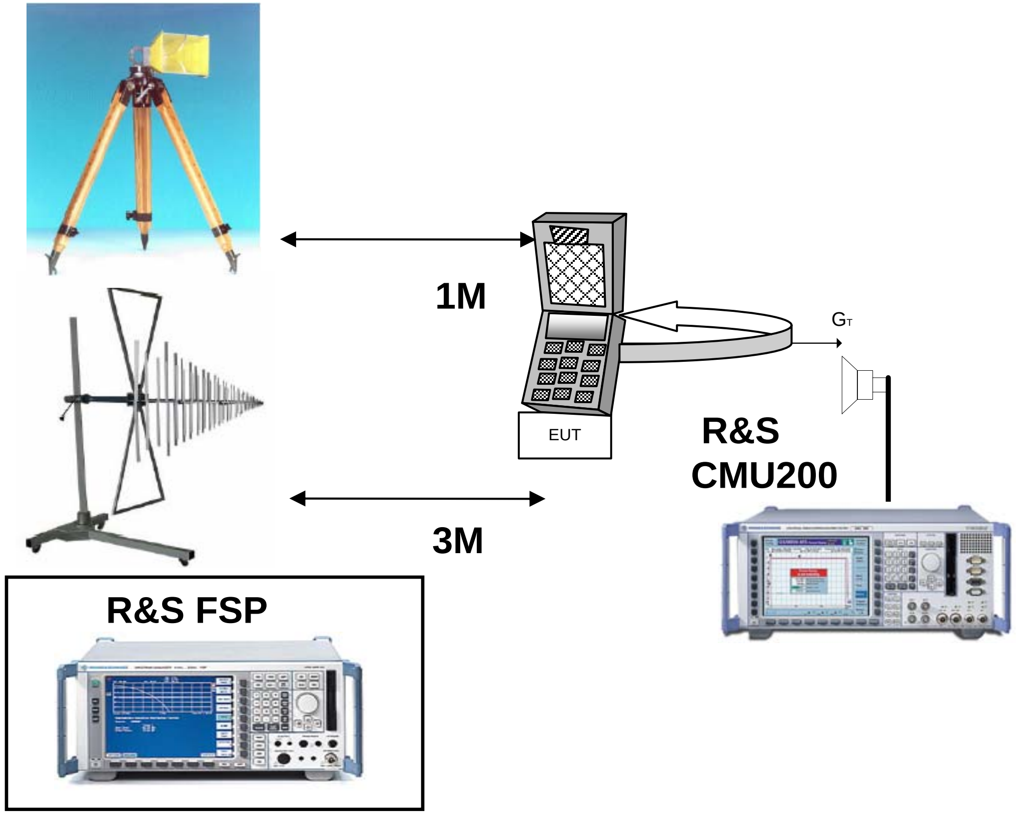


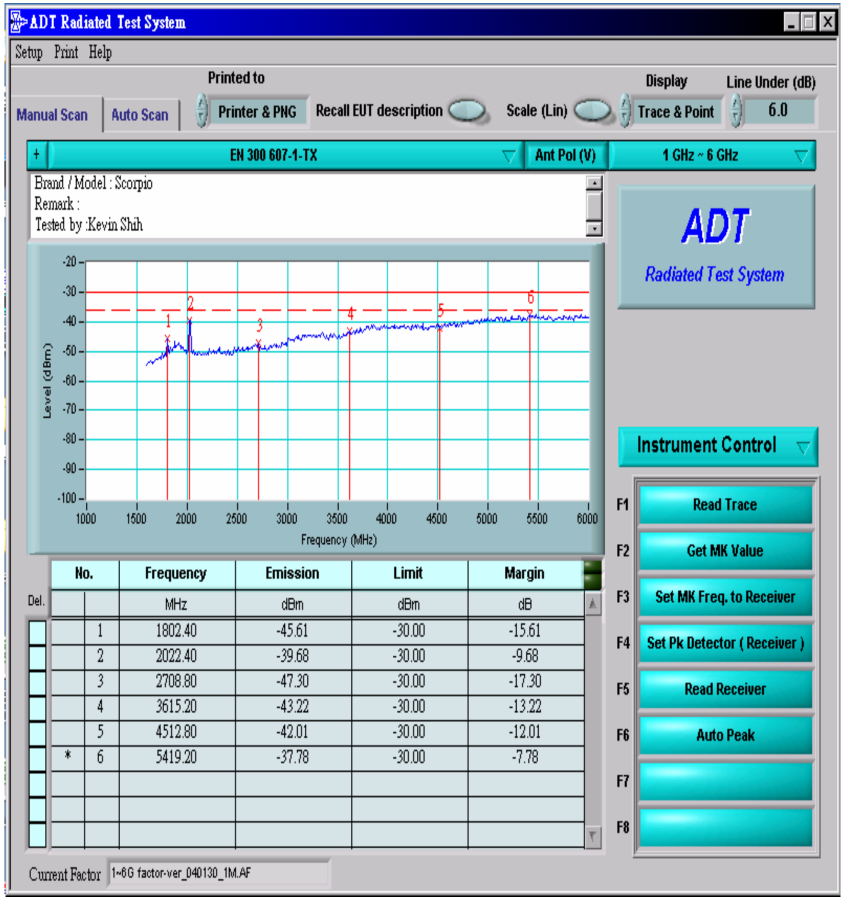
2D EIRP & Wireless sensitivity



2D Antenna Gain and Pattern

Radiated Spurious Test





Printed to: Printer & PNG

Recall EUT description

Scale (Lin)

Display: Trace & Point

Line Under (dB): 6.0

EN 300 607-1-TX

Ant Pol (V)

1 GHz ~ 6 GHz

Brand / Model : Scorpio
Remark :
Tested by :Kevin Shih

Del.		No.	Frequency	Emission	Limit	Margin
			MHz	dBm	dBm	dB
☐		1	1802.40	-45.61	-30.00	-15.61
☐		2	2022.40	-39.68	-30.00	-9.68
☐		3	2708.80	-47.30	-30.00	-17.30
☐		4	3615.20	-43.22	-30.00	-13.22
☐		5	4512.80	-42.01	-30.00	-12.01
☐	*	6	5419.20	-37.78	-30.00	-7.78
☐						
☐						
☐						

Current Factor: 1~6G factor-ver_040130_1M.AF

Q&A