Government of India
Ministry of Communications
Department of Telecommunications
(Access Services Wing)
Sanchar Bhawan, 20, Ashoka Road, New Delhi

File No.: 800-15/2010-VAS **Dated: 09.10.2023**

To

All UAS /UL (having Access Service Authorization) Licensees

Subject: Addendum to TEC Test Procedure for Measurement of Electromagnetic Field from Base Station Antenna (TEC 13019:2021) - for measurement of EMF Exposure from 5G Base Stations-reg

The terms & conditions of the Unified License agreement, inter-alia, provide that "... *the Licensee shall conduct audit and provide self certificate, at prescribed interval and as per procedure prescribed by Telecommunication Engineering Centre (TEC) / or any other agency authorized by Licensor from time to time for conforming to limits / levels for antenna (Base Station Radiation Emissions) for general public exposure as prescribed by Licensor from time to time... ".* Similar terms and conditions is present in UAS license agreement.

2. TEC has issued Addendum to TEC Test Procedure for Measurement of Electromagnetic Field from Base Station Antenna (TEC 13019:2021) for measurement of EMF Exposure from 5G Base Stations. A copy of the addendum issued by the TEC is hereby enclosed for information and necessary action on part of all licensees. For any technical query, TEC may be contacted directly.

Encl.: As above.

Nisha 9.10.23

(Nisha)
ADG (AS-II)
Tele No.: 011-23310180

Copy to:

1. DG (T), DoT HQ, New Delhi- for kind information and necessary action.
2. Sr. DDG, TEC, New Delhi.
3. DDG (CS), New Delhi.

ADDENDUM I

to

TEC TEST PROCEDURE FOR MEASUREMENT OF ELECTROMAGNETIC FIELD FROM BASE STATION ANTENNA (TEC 13019:2021)

for

EMF EXPOSURE MEASUREMENT IN 5G

This Addendum provides procedure to carry out broadband and frequency selective EMF exposure measurement for 5G technology. This document may be read in conjunction with the TEC Test Procedure for Measurement of Electromagnetic Field from Base Station Antenna (TEC 13019:2021).

NOTE 1: *All the measurements specified in this Addendum, for assessing EMF exposure from 5G Base Stations with beam forming antennae, may be carried out by generating traffic using 5G UEs (high data rate downloads, standard speed tests etc) so that the Base Station serving beam(s) are directed towards the evaluation location. This approach yields RF exposure results for different Base Station loading conditions and is particularly useful when measurements are performed in networks characterized by extremely low traffic (e.g. when a new technology is deployed)*[1]

1. Broadband Measurement

Broadband measurement is to be conducted for the frequency range from 450 MHz to 4 GHz. Broadband measurement of power density (W/m^2) may be done with an isotropic field probe.

Broadband measurements will be done for first stage audit verification by LSA Unit to certify EMF compliance of a site subject to the condition that measured values do not exceed 50% of DoT prescribed limits in terms of power density value.

NOTE 2: *The isotropic field probes are generally not feasible at frequencies greater than 6 GHz. In such case, frequency selective measurements need to be carried out.*

1.1. Method 1:

Single broadband measurement over frequency range 450 MHz to 4 GHz. In this case, the lowest applicable exposure limit for the frequencies present shall be used to determine the combined exposure ratio expressed as a fraction/percentage of the applicable limit.

NOTE 3: *This is applicable in case measuring instrument has flat frequency response probe and hence, is capable of operating accurately over the aggregate signal band.*

i.e. if S = measured time-averaged power density over 450 MHz < f < 4000 MHz

and, f_{min} = minimum frequency (in MHz) present at the site.

then, $$Exposure\ ratio\ = \frac{S}{S_{Th}}$$

where, $$S_{Th} = \begin{cases} \frac{f_{min}}{2000},\ if\ f_{min} < 2000 \\ 1,\ if\ f_{min} \geq 2000 \end{cases}$$ (in W/m^2)

1.2. Method 2:

Conducting Broadband Measurements separately over frequencies as shown in Table I below:

Table I: Broadband Measurement

Reading	**Frequency Range** (in MHz)	**Measured Power Density** (in W/m^2)	**Applicable Threshold*** S_{Th} (in W/m^2)
1	450 < f < 2000	S_1	$\frac{f_{min}}{2000}$
2	2000 < f < 3000	S_2	1
3	3000 < f < 4000	S_3	1

*This shall be as per DoT prescribed limits.

$$Total\ Exposure\ ratio\ = \sum_{i=1}^{3} \frac{S_i}{S_{Th}} \text{ x } 100\%$$

Result Analysis: If total Exposure ratio is greater than 50%, then frequency selective measurement should be conducted. If the exposure ratio is less than 50% then site is compliant.

2. Frequency Selective Measurement

Frequency selective measurements with extrapolation for maximum traffic must be performed if the broadband measurement exceeds 50 % of limits prescribed by DoT.

Frequency Selective Measurement for 5G Technology Base Stations shall be carried out using channel decoding or spectrum analysis.

2.1. 5G NR measurement using 5G NR Decoder (applicable for all frequencies)

The measurement method is based on determination of the field strength of the secondary synchronization signals (SSS) in the Synchronization Signal Block (SSB) of the downlink. In this mode the instrument shall determine the field strength $E_{SSS,RE}$ that is generated per resource element by the SSS, by averaging across all 127 subcarriers of the SSS.

i. 5G NR Channel Selection: By entering precise Centre frequency of the SSB of the 5G channel to be measured

ii. Demodulation Algorithm: SSS signal
iii. Subcarrier Spacing (SCS) (for sub 6 GHz frequency): 15 kHz, 30 kHz (as per network deployment)
iv. Subcarrier Spacing (SCS) (for above 6 GHz frequency):120 kHz and 240 KHz (as per network deployment)
v. Measurement Results:
    - Strongest value of SSS 0 – SSS 7 (SSS Max) for sub 6 GHz frequency
    - Strongest value of SSS 0 – SSS 63 (SSS Max) for above 6 GHz frequency
vi. Result Type: Max Hold function
vii. Table layout Index: Cell ID, No. of SSSs, Cell specific SSS signals for selected result types for primary cell identifier (PCI) for each 5G NR signal captured.

NOTE 4: *This method relies on calculation of extrapolated electric field strength on the basis of measurement of SSS signal of broadcast channel. Hence, it is important that 'max Hold' feature in the measurement instrument is used to capture the maxima of broadcast beam(s). To ensure that, spatial sweeping can be done at the point of evaluation to get maxima of the broadcast beam(s).*

2.1.1 Extrapolation of measurement results

For the extrapolation of 5G signals several parameters have to be considered due to the use of TDD and beam forming. The measurements require that the system bandwidth and centre frequency of the target NR carrier SSB are set. The extrapolated electric field strength ($V.m^{-1}$) E_{asmt} (assessment electric field strength) is defined by following Equation.

$$E_{asmt} = E_{SSB} \cdot \sqrt{F_{extBeam} \cdot F_{BW} \cdot F_{PR} \cdot F_{TDC} \cdot F_B^{-1}}$$

Where

E_{SSB} is the measured electric field level ($V\ m^{-1}$) per resource element (RE) of the strongest SSB;

F_{TDC} is the technology duty-cycle;

F_{PR} is the power reduction if the actual maximum approach is used, otherwise it is set to 1;

$F_{extBeam}$ is the extrapolation factor corresponding to the ratio of the traffic radiation pattern envelope to the broadcast radiation pattern envelope at the direction to the evaluation location. If beam forming is not used at Base station, $F_{extBeam} = 1$;

F_B is the ratio of the power transmitted for the SSB symbol to the traffic symbol (boosting factor). F_B is set to 1 if the power for the SSB and traffic symbols is the same or if the difference in power is already factored in $F_{extBeam}$;

F_{BW} is the ratio of the total carrier bandwidth and the subcarrier frequency spacing of the SSB;

F_{extSSB} is the extrapolation factor for the SSB.

When the power allocated to any subcarrier is the same, F_{BW} corresponds to the number of resource elements. The extrapolation factor, F_{BW}, for each system bandwidth is shown in Table II and III below assuming that all subcarriers are transmitted with the same power level.

Table II: F_{BW} for each combination of BS channel bandwidth and SSB subcarrier spacing (SCS) for sub-6 GHz signals

SCS	Bandwidth (MHz)												
[kHz]	5	10	15	20	25	30	40	50	60	70	80	90	100
15	300	624	948	1 272	1 596	1 920	2 592	3 240	n/a	n/a	n/a	n/a	n/a
30	132	288	456	612	780	936	1 272	1 596	1 944	2 268	2 604	2 940	3 276
60	n/a	132	216	288	372	456	612	780	948	1 116	1 284	1 452	1 620
n/a = not applicable.													

Table III: F_{BW} for each combination of BS channel bandwidth and SSB subcarrier spacing (SCS) for mm-wave signals

SCS [kHz]	Bandwidth (MHz)			
	50	100	200	400
60	792	1 584	3 168	n/a
120	384	792	1 584	3 168
n/a = not applicable.				

In order to distinguish between the contribution of different cells E_{SSB} should correspond to the RF field strength per RE of the decoded SSS.

2.2. Alternative Method using a spectrum analyzer

The spectrum analysis method can be used if decoding solutions are not available. The following configuration parameter recommendations apply for the measurement: -

i. The centre frequency of the spectrum analyser should be set at center frequency of the SSB of 5G NR signal under evaluation.
ii. The frequency span should be set to zero (scope mode) in order to measure the received time signal for the SSB.
iii. The resolution bandwidth (RBW) should be set smaller than 127 sub-carriers (e.g. 1MHz)
iv. The detector should be set to root mean square (RMS) detector mode. When using RMS detector mode, the VBW should either be equal to or higher than the RBW or switched off to avoid underestimation.
v. If RMS detector mode is not available, the spectrum analyser can be set to peak or sample mode. In such case, a VBW smaller than RBW should be used to avoid overestimation. (e.g. 10 kHz for 5G NR FR1 with SCS of 30 kHz using RBW of 1 MHz; and 30 kHz for NR FR2 with SCS of 120 kHz using RBW of 1 MHz).

vi. If possible, the sweep time may be set equal to approximately the product of the number of display points of the SA and the symbol duration in order to obtain an integration time close to the symbol duration of each pixel on the screen of the SA.

vii. The measurements may be done with Max Hold conditions for minimum 6 minutes.

viii. Apply a factor of √**(SCS / RBW)** to the measured field value in order obtain the RF field strength per RE.

NOTE 5: In this method, Spectrum analyser is used to measure field strength per RE which corresponds to E_{SSB} measured in 5G-NR decoder-based method. Hence, the value obtained above should be put in extrapolation formula given in clause 2.1.1.

NOTE 6: Based on the extrapolated electric field strength ($V.m^{-1}$) i.e. E_{asmt} (assessment electric field strength) calculated from the extrapolation of frequency selective measurements, the total exposure index for the site under assessment may be calculated as prescribed in Appendix E of the TEC Test Procedure For Measurement Of Electromagnetic Field From Base Station Antenna (TEC 13019:2021)

References

[1] IEC 62232:2022 “Determination of RF field strength, power density and SAR in the vicinity of base stations for the purpose of evaluating human exposure”

Annexure I

Format for 5G frequency selective measurement for certification of base stations for compliance with the safe limits for EMF exposure from cellular radio base stations

Table IV: Technical parameters for base stations within 60-meter radius of the location under consideration

Parameters	**Operator 1**	**Operator 2**	**Operator 3**	**Operator n**
Base Station ID (s)				
Date of Commissioning				
Address				
Town/Village				
District				
State/UT				
Pincode				
Tower Type (RTT/GBT etc)				
Frequency Band				
Base Station Technology				
Cell SSB arfcn / SSB center frequency				
Subcarrier spacing SCS				
TDD Configuration/Duty Cycle, if applicable				

Channel bandwidth (CBW)				
Mounting height of the antennas above ground (lower edge)				
Horizontal alignment (main beam direction) of the sector to be examined and, if applicable, for relevant sectors of neighboring cells				
Mechanical tilt				
Digital tilt, if applicable				
Maximum gain of antenna				
Maximum scan range of antenna in the horizontal plane				
Maximum scan range of antenna in the vertical plane				
Total rated maximum Tx power				
Maximum EIRP				
Boosting Factor (F_B)				
Power Reduction Factor (F_{PR})				
Beam Forming Factor ($F_{extBeam}$)				

Annexure II

General operational guidelines for using EMF measurement instrument for carrying out EMF measurement (For information only)

1. Broadband Measurement

1.1. Guidelines for Method 1

i. Connect isotropic antenna to EMF measuring equipment that has operating frequency range 450 MHz to 4 GHz.
ii. Set appropriate value of "Meas. Range" parameter.
iii. Make sure the appropriate RBW value (e.g 200 kHz or 1MHz) has been set.
iv. Set fmin = 450 MHz and fmax = 4 GHz in the instrument for obtaining single reading of broadband measurement for given frequency range.
v. Make sure that the Result unit is W/m² for measuring power density.
vi. Set Averaging time as 6 min.
vii. The "Result Type" should be selected as "Average".
viii. Calculate the exposure ratio. If value comes under 0.5 then site is compliant else proceed with frequency selective method.

1.2. Guidelines for Method 2

i. Connect isotropic antenna to EMF measuring equipment that has operating frequency range 450 MHz to 4 GHz.
ii. Set appropriate value of "Meas. Range" parameter.
iii. Make sure the appropriate RBW value (e.g 200 kHz or 1MHz) has been set.
iv. Select fmin and fmax for multiple broadband readings as per the band segmentation mentioned in the main document.
OR
Create a Service Table (pre-configured fmin and fmax for three bands mentioned in main document) (if supported by instrument) for taking broadband reading in single go.
v. Make sure that the Result unit is W/m² for measuring power density.
vi. Set Averaging time as 6 min.
vii. The "Result Type" should be selected as "Average"
viii. Calculate the total exposure ratio. If value comes under 0.5 then compliant else proceed with frequency selective method.

2. Frequency Selective Measurement

2.1. Guidelines for Code-Selective Method using 5G NR Decoder

i. Connect antenna of suitable operating frequency range (corresponding to operating frequency of 5G base station)
ii. Select 5G NR Option or its equivalent in the measuring instrument for decoding 5G NR signals.
iii. Set Centre Frequency (corresponding to operating frequency of 5G base station/SSB)

iv. Set suitable Measurement Range
v. Select Result Type (Max)
vi. Set SCS as per SCS parameter of base station under consideration.
vii. Set appropriate sensitivity for decoder based measurement. The sensitivity value/setting may vary with measurement location.
viii. Select Signal (SSS having significant E field values within measurement site area)
ix. Measure E_{SSB} by spatial averaging for 6 minutes
x. Extrapolate the field strength value using the extrapolation formula provided in main document of Addendum under clause 2.1.1
xi. Calculate the total exposure ratio. If the value comes under 1 then site is compliant else not compliant.

2.2. Guidelines for Spectrum Analyzer method

i. Connect antenna of suitable operating frequency range (corresponding to operating frequency of 5G base station)
ii. The centre frequency of the spectrum analyser should be set at center frequency of the SSB of 5G NR signal under evaluation.
iii. The frequency span should be set to zero span (scope mode or a mode which is analogous to zero span i.e. RBW can be fixed over a fixed frequency span) in order to measure the received time signal for the SSB.
iv. The resolution bandwidth (RBW) should be set smaller than 127 sub-carriers (e.g. 1MHz)
v. The detector should be set to root mean square (RMS) detector mode. When using RMS detector mode, the VBW should either be equal to or higher than the RBW or switched off to avoid underestimation.
vi. If RMS detector mode is not available, the spectrum analyser can be set to peak or sample mode. In such case, a VBW smaller than RBW should be used to avoid overestimation. (e.g. 10 kHz for 5G NR FR1 with SCS of 30 kHz using RBW of 1 MHz; and 30 kHz for NR FR2 with SCS of 120 kHz using RBW of 1 MHz).
vii. If possible, the sweep time may be set equal to approximately the product of the number of display points of the SA and the symbol duration in order to obtain an integration time close to the symbol duration of each pixel on the screen of the SA.
viii. The measurements may be done with Max Hold conditions for minimum 6 minutes.
ix. Apply a factor of $\sqrt{}$ (SCS / RBW) to the measured field value in order obtain the RF field strength per RE.
x. In this method, Spectrum analyser is used to measure field strength per RE which corresponds to E_{SSB} measured in 5G-NR decoder-based method. Hence, the value obtained above should be put in extrapolation formula provided in main document of Addendum under clause 2.1.1.

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