Technology Reports (Special Articles)

5G Mobile Terminals | Mobile Terminal Wireless Unit Configuration | Heat Control

Special Articles on 5G (2)—NTT DOCOMO 5G Initiatives for Solving Social Problems and Achieving Social Transformation—

Mobile Terminals for 5G Communications

Communication Device Development Department Yusaku Inoue Yuta Oguma
Satoshi Tarouda
Product Department Tetsuya Inagaki Young-Cheol Yu
Naoya Sato

The introduction of 5G will enable more comfortable communications on mobile terminals thanks to its high speed, large capacity and low latency. Meanwhile, due to the expected future increases in traffic volume and the need for further improvement in throughput, NTT DOCOMO has been studying EN-DC, which combines the new 5G frequency bands with the existing 4G frequency bands. In this article, to handle the new 5G frequencies, we describe an overview of the newly developed mobile terminals, RF configurations, standardized test methods, heat countermeasures, and NTT DOCOMO's future mobile terminal development initiatives.

1. Introduction

In April 2019, the Ministry of Internal Affairs and Communications announced the allocation of new frequencies for the 5th generation mobile communications system (5G), and newly allocated frequencies in the 3.7 GHz band (3.6 to 3.7 GHz), the 4.5 GHz band (4.5 to 4.6 GHz) and the 28 GHz band

(27.4 to 27.8 GHz) to NTT DOCOMO. NTT DOCOMO launched communications services capable of up to 3.4 Gbps downlink in March 2020 and up to 4.1 Gbps downlink in September of the same year, using Evolved Universal Terrestrial Radio Access Network New Radio Dual Connectivity (EN-DC)*1, which combines the new 5G frequency bands with the existing 4G frequency bands.

In this article, with the introduction of the new 5G frequency bands, we describe NTT DOCOMO's technological development efforts to contribute to 3GPP formulation of standard specifications, the Radio Frequency (RF)*2 configuration that realizes the EN-DC combination of the new 5G and existing 4G frequency bands, and describe the standard test method for the new 28 GHz band introduced in 5G. In addition, we describe heat countermeasures to enable users to use mobile terminals safely and securely, since increases in mobile terminal power consumption is accompanied by increased heat generation.

2. Features of 5G Devices

There are a wide variety of 5G mobile devices. These include data communication devices and communication modules such as smartphones, mobile Wi-Fi routers, and Customer Premises Equipment (CPE) like indoor routers. These 5G-enabled devices have evolved from LTE, and offer real-time, more realistic user experiences through high speed, large capacity, low latency, and multi-terminal connections.

With the aim of popularizing new experiences, NTT DOCOMO is providing a total of seven 5G-enabled devices during the introduction phase of 5G services - four Sub6*3 + LTE-enabled smartphones, two millimeter Wave (mmW)*4 + Sub6 + LTE-enabled smartphones, and one Wi-Fi router (**Figure 1**). All new high-spec smartphone models in spring-summer 2020 are 5G-enabled, with throughput of up to 3.4 Gbps downlink and 182 Mbps uplink with Sub6-enabled models, and up to 4.1 Gbps downlink

	AQUOS R5G	Galaxy S20 5G	LG V60 ThinQ 5G	Xperia 1II	Galaxy S20+5G	arrows5G	Wi-Fi STATION (SH)
	High-spec model	High-spec model	High-spec model	High-spec model	High-spec model	High-spec model	High-spec model
Image	Sub6 	Sub6 	Sub6 	Sub6 	mmW Sub6 	mmW Sub6 	mmW Sub6 
Release Date	March 25, 2020	March 25, 2020	May 11, 2020	June 18, 2020	June 18, 2020	July 30, 2020	June 1, 2020

Figure 1　New 5G-enabled devices in spring-summer 2020

*1　EN-DC: An architecture for 5G NSA operations, using 5G as another radio resource in addition to the RRC connection over 4G radio.

*2　RF: The radio frequency circuit.

*3　Sub6: A division of the frequency band. A radio signal with a frequency between 3.6 GHz and 6 GHz.

*4　mmW: A division of the frequency band. A radio signal with a frequency between 30 GHz and 300 GHz.

and 480 Mbps uplink with mmW-enabled models. In addition, device specifications, which show the remarkable evolution of underlying technologies, include display: Organic Light Emitting Diode (OLED) mainstream, ultra-thin bezel; battery: larger capacity; camera: multi-lens, Artificial Intelligence (AI) utilization; Central Processing Unit (CPU)/Graphics Processing Unit (GPU): high-performance and low-power processing; memory: more than 10 GB Random Access Memory (RAM), etc.

"Evolution from LTE" and "connectivity as a hub" are two features implemented and embodied in these 5G devices.

First, with "evolution from LTE," devices have processing power, display size, battery capacity, etc. that enable use cases including improved real-time viewing of eSports, multi-angle viewing of sports games, recording/sharing 8K videos, and more.

With "connectivity as a hub," particular efforts have been made to enhance external interface functions to connect with various peripheral devices. Specifically, support for DisplayPort*5 over USB Type-C*6, connectivity with Wi-Fi 6 (IEEE 802.11ax*7) tethering, and improved end-to-end communications speeds allow users to experience 5G on connected peripheral devices.

3. Terminal Radio Unit Configuration for 5G Communications

3.1 Handling Frequencies

In 3GPP standard specifications, frequency bands are generally classified into the following two frequency ranges.

- FR1 (Frequency Range 1): 450 to 6,000 MHz
- FR2 (Frequency Range 2): 24,250 to 52,600 MHz

FR1 consists of two frequency bands - a frequency band the same as an existing 4G frequency band and the new 5G frequency bands. The new frequency bands allocated for 5G in Japan are the 3.7 GHz band (n77, n78), the 4.5 GHz band (n79), and the 28 GHz band (n257). n77, n78, n79 and n257 represent the Time Division Duplex (TDD) frequency bands defined for New Radio (NR). Among them, the frequencies allocated to NTT DOCOMO are 3.6 to 3.7 GHz, 4.5 to 4.6 GHz, and 27.4 to 27.8 GHz, as shown in **Figure 2**. The domestic law for the use of an existing 4G frequency band for 5G came into force on August 27, 2020. Use of it is expected in Japan in the future.

5G methods include Stand Alone (SA)*8 and Non-Stand Alone (NSA)*9 [1], while mobile terminals in spring-summer 2020 are NSA-enabled. In NSA, EN-DC technology combining 4G and 5G frequency bands is used. As shown in **Table 1**, we developed mobile terminals equipped with an EN-DC combination of the existing 4G frequency bands and the 3.7 GHz, 4.5 GHz and 28 GHz bands. Using the 3.7 GHz band and 4.5 GHz band achieves up to 3.4 Gbps downlink and up to 182 Mbps uplink. Using the 28 GHz band achieves up to 4.1 Gbps downlink and up to 278 Mbps uplink. Uplink throughput of up to 480 Mbps is planned for the future.

3.2 Terminal Radio Unit Configuration Implementation Method

Since both the 3.7 GHz and 4.5 GHz bands were scheduled to be allocated in Japan, the coexistence

---

*5 DisplayPort: A video output interface standard established by the Video Electronics Standards Association.

*6 USB Type-C: A connector standardized by the USB Implementers Forum.

*7 IEEE 802.11ax: A wireless standard defined by IEEE that utilizes the 2.4 GHz and 5 GHz bands, and supports a transfer rate of 9.6 Gbps.

*8 SA: Stand-alone format. A form of mobile communication network on which terminals connect using a single wireless technology.

*9 NSA: Non stand-alone format. A form of mobile communication network on which terminals connect via multiple radio technologies.

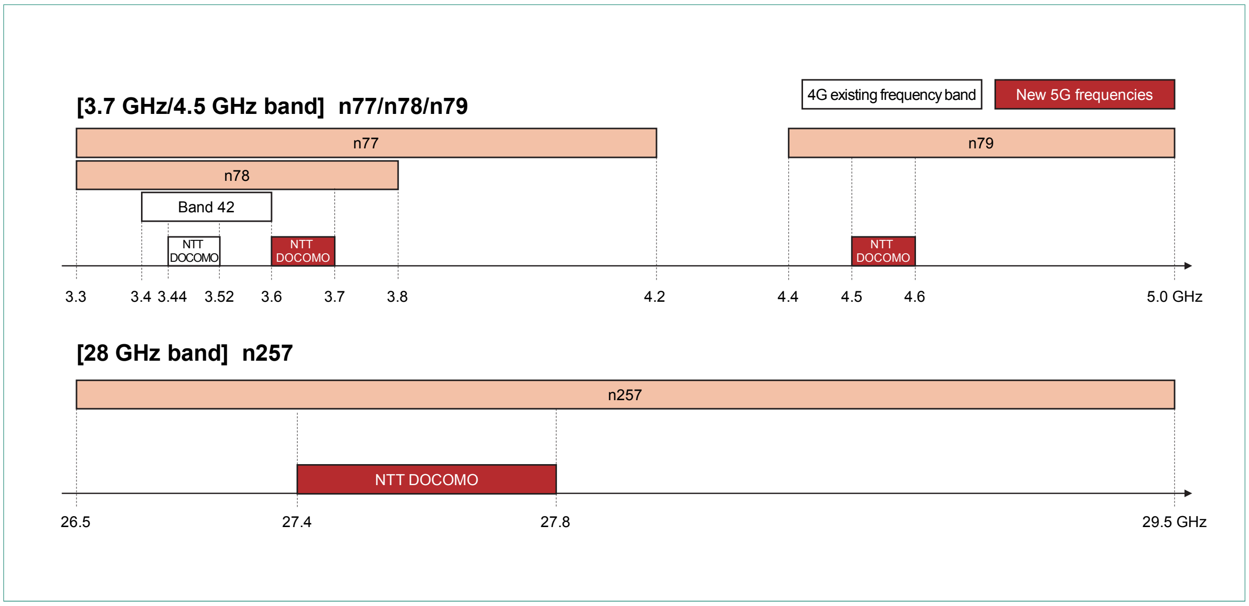

Figure 2 New 5G frequencies allocated to NTT DOCOMO

Table 1 EN-DC band combination example

EN-DC band combination	Frequency band
Band 1 + n78	2 GHz (20 MHz) + 3.7 GHz (100 MHz)
Band 1 + n79	2 GHz (20 MHz) + 4.5 GHz (100 MHz)
Band 1 + n257	2 GHz (20 MHz) + 28 GHz (400 MHz)
…	…
Band 1 + Band 3 + Band 42 + n78	2 GHz (20 MHz) + 1.7 GHz (20 MHz) + 3.5 GHz (20 MHz x 3) + 3.7 GHz (100 MHz)*1
Band 1 + Band 3 + Band 42 + n79	2 GHz (20 MHz) + 1.7 GHz (20 MHz) + 3.5 GHz (20 MHz x 3) + 4.5 GHz (100 MHz)*1
…	…
Band 1 + Band 3 + Band 42 + n257	2 GHz (20 MHz) + 1.7 GHz (20 MHz) + 3.5 GHz (20 MHz x 3) + 28 GHz (100 MHz)*2

*1 EN-DC band combination when 3.4 Gbps achieved
*2 EN-DC band combination when 4.1 Gbps achieved

of the 3.7 GHz and 4.5 GHz bands was discussed at a 3GPP Standardization Meeting. When conventional regulations for protections between frequency bands were applied to the 3.7 GHz and 4.5 GHz bands, there were concerns about reducing uplink coverage by reducing the transmission power of mobile terminals for mutual protection, or high costs related to installing expensive filters, from the perspectives of the proximity of the frequency bands, and the fact that the bands are high frequencies. For this reason, NTT DOCOMO studied the interference between the 3.7 GHz and 4.5 GHz bands with other telecommunications carriers in Japan, and examined appropriate protection regulations that would not require a decrease in transmitted power or expensive filtering, as long as there were no interference impacts. At the 3GPP Standardization Meeting, NTT DOCOMO agreed to propose the above protection regulations under a joint name of domestic telecommunications carriers to secure uplink coverage and achieve low-cost devices. As a result, it was possible to satisfy standard specifications with low-loss, low-cost LC filters*10.

A typical RF configuration for EN-DC is shown in **Figure 3**. To realize EN-DC, the two frequency bands must be separated to enable simultaneous communication. There are two methods to achieve this. One is to place a filter (demultiplexer*11) directly below the antenna to separate the multiple frequency ranges at low loss (Low band*12, Mid band*13, Ultra-high band*14 (4.5 GHz band) separation). The other is to separate the antennas at each frequency used for simultaneous communication (Ultra-high band (3.7 GHz band) separation). The technical issue when using a demultiplexer is how to suppress signal power loss due to the pass loss of the device, while the issue with separating antennas is maintaining a compact size because more area is required for antennas. Since the 3.7 GHz and 4.5 GHz bands must be equipped with four receiving antennas in standard specifications, we devised and implemented the RF configuration in light of the aforementioned issues.

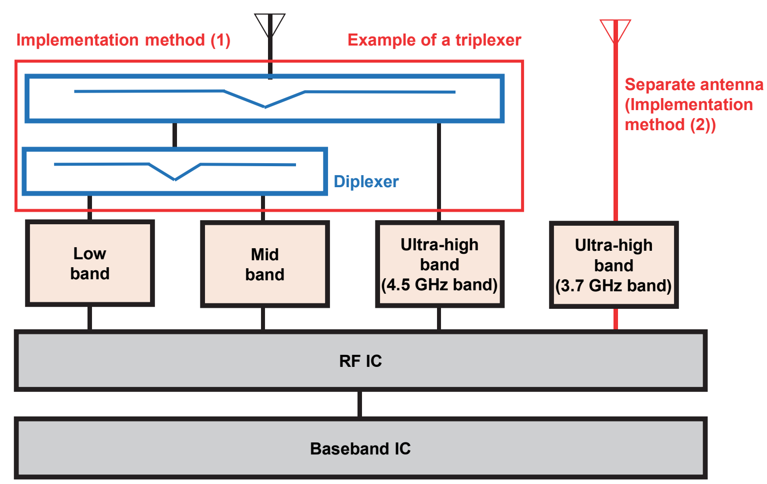

Figure 3　RF configuration example

*10 **LC filter:** A type of filter with relatively low attenuation characteristics for interference signals, but that can be implemented with low loss and low cost.

*11 **Demultiplexer:** A low-loss filter for separating multiple frequency bands. Called a “diplexer” when separating two frequency bands and a “triplexer” when separating three frequency bands. A diplexer consists of a low-pass filter (a filter that allows low frequencies to pass, but attenuates high frequencies) and a high pass filter (a filter that allows high frequencies to pass, but attenuates low frequencies).

*12 **Low band:** Band 28 (700 MHz) and Band 19 (800 MHz) among the frequencies used by NTT DOCOMO.

*13 **Mid band:** Band 21 (1.5 GHz), Band 3 (1.7 GHz) and Band 1 (2 GHz) among the frequencies used by NTT DOCOMO.

*14 **Ultra-high band:** Band 42 (3.5 GHz), Band n77/n78 (3.7 GHz) and Band n79 (4.5 GHz) among the frequencies used by NTT DOCOMO.

4. Evaluation of FR2 RF Performance of 5G Terminals

In this section, we describe the RF performance evaluation method in mobile terminals for the mmW frequency band defined by NR (FR2 frequency band in 3GPP).

4.1 Evaluation Method of FR2 RF Performance

With the integration of the transceiver and antenna in FR2, since it is not possible to measure with a connector, Over The Air (OTA)*15 provisions were introduced as RF specifications. The OTA provisions define Equivalent Isotropic Radiated Power (EIRP)*16 in the beam direction including antenna characteristics, Total Radiated Power (TRP) that specifies the total power emitted from the device, and Equivalent Isotropic Sensitivity (EIS)*17 [1]. The 3GPP standard specifications in Release 15 define three measurement systems to achieve EIRP, TRP, and EIS measurements: Direct Far Field (DFF)*18, Indirect Far Field (IFF)*19, and Near Field To Far-field (NFTF)*20. Currently, IFF measurement methods achievable with comparatively small test systems are becoming popular. The following describes the Compact Antenna Test Range (CATR), an IFF measurement technique, and a measurement system for FR2 RF performance evaluation.

Figure 4 shows a schematic of CATR. With measurement of antenna radiation characteristics such as EIRP, TRP and EIS, the distance between the Device Under Test (DUT) and the measurement antenna must be the distance to satisfy far field*21 conditions, so that the radio waves received by the DUT or the measurement antenna become

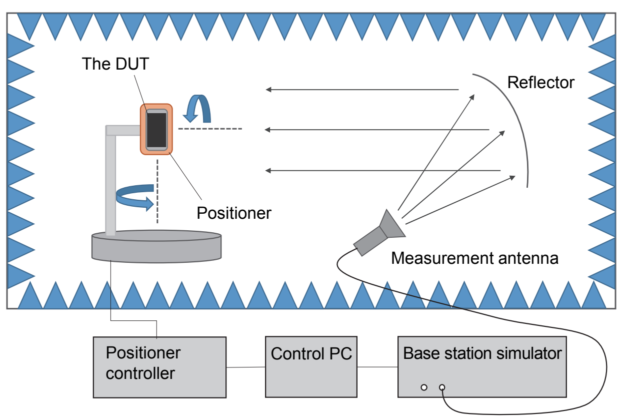

Figure 4 CART schematic

*15 OTA: A method for measuring radio characteristics transmitted or received from a base station or terminal, by positioning it opposite a measurement antenna. Equipment configurations without antenna connectors have been defined and specified in this test method for NR base stations and terminals.

*16 EIRP: The transmission power at a specified reference point in radio radiation space.

*17 EIS: The received power at a specified reference point in radio reception space.

*18 DFF: The basic measurement system in OTA measurement. The DUT and the measuring antenna are opposed each other. The distance between the DUT and the measurement antenna must fulfill far-field conditions.

*19 IFF: A pseudo far-field measurement system. A spherical wave is converted into a planar wave through a reflector on the propagation path between the DUT and the measurement antenna.

planner waves*22. The distance to satisfy the far field condition depends on the size of the DUT and the wavelength. Assuming the size of a typical smartphone or tablet terminal, for example, a distance of about 17 m or more would be required for the 28 GHz band, meaning a large measurement system would be required. However, converting from spherical wave to planar wave by a reflector in CATR eliminates the limitation by the far field conditions so that the measurement system can be miniaturized. This also improves transmission and reception dynamic range*23 because the path length between the DUT and the measurement antenna is shortened, which reduces path loss.

1) EIRP Measurement Procedure

As shown in Fig. 4, the DUT is installed on the positioner and connected to the base station simulator.

After connection, the radio waves emitted from the DUT are received at the measurement antenna and the received power is measured. The EIRP is calculated by adding corrections such as propagation loss*24 and cable loss to the measured received power. The positioner is a mechanism for rotating in the horizontal and the vertical directions on a central axis to freely control the relative direction between the DUT and the measurement antenna. This mechanism makes it possible to measure EIRP in any direction on a spherical surface centered on the DUT. Note that the spacing between measurement points on the sphere is defined as a measurement grid. In addition, unlike the TRP measurement procedure described later, the test is carried out without fixing the transmission beam direction of the mobile terminal.

2) TRP Measurement Procedure

The concept of measurement points is similar to 1). TRP is calculated based on the EIRP measured using the measurement grid. However, with TRP measurement, the mobile terminal transmission beam is fixed in the maximum transmission beam direction, and the measurement is performed with the transmission beam direction unchanged for each measurement point.

3) EIS Measurement Procedure

The basic measurement procedure is similar to 1) and measures the reception sensitivity including antenna gain*25 at each measurement point on the spherical surface centered on the DUT. The specific reception sensitivity definition refers to received power that can achieve 95% of the maximum value as throughput on reception of signals from the measurement antenna.

4.2 5G Terminal Transmission and Reception Performance in FR2

EIRP and EIS measurements were performed on FR2-enabled 5G mobile terminals. Using the aforementioned CATR as the measurement system, peak values and spherical coverage (EIRP/EIS values satisfied by 50% of the area) were calculated from the EIRP and EIS values at each measurement point. The test was also performed with the FR2 band measured as n257, with measurements performed with both the elevation angle and the azimuth angle at 15° as the interval between measurement points.

The measured/calculated EIRP/EIS peak values and spherical coverage (@50%-tile Cumulative

*20 NFTF: In this measurement system, the DUT and the measurement antenna are opposed to each other, as in the case of DFF. However, the distance between the DUT and the measurement antenna is shorter than the distance in far-field conditions, and the obtained measurement results are converted to far-field measured values.

*21 Far field: The region where the electromagnetic field radiated from an antenna is determined only by its direction function and does not depend on the distance to the point of observation.

*22 Planar wave: An electromagnetic wave where the amplitude and phase of the electromagnetic field are constant within a plane perpendicular to the propagation direction.

*23 Dynamic range: The range of input signal that can be processed without distortion.

Distribution Function (CDF)*26) and their respective 3GPP specification values are shown in **Figure 5**. It can be confirmed that the EIRP and EIS peak values meet the 3GPP standard specifications.

5. Heat Countermeasures for 5G Terminals

5.1 User Safety

NTT DOCOMO attaches great importance to the development of mobile terminals in terms of the safety and convenience of users. Especially for the Japanese market, mobile terminals are developed with the minimum condition that they will not cause burns under any load, and are developed with the aim of not impairing merchantability while minimizing the heat that users feel during use.

5.2 NTT DOCOMO Temperature Rise Standards

As temperature rise standards that mobile terminals must satisfy, we first set a standard (1) for low temperature burns so that terminals can be used safely. We referred to ISO 13732-1 [2] for standard temperatures referred to by Mobile Computing Promotion Consortium (MCPC) [3].

Furthermore, based on user feedback about all mobile terminals sold to date, we set standards (2) and (3) so that users can use terminals comfortably (so that mobile terminals do not get hot).

(1) Temperature rise standards to prevent low temperature burns

The maximum temperature rise of parts in contact with the user is set so that low temperature bums cannot occur when the user touches the terminal surface under its highest load.

(2) Temperature rise standards for communications/calling

The maximum temperature rise when a single function related to communications and calling is running is set.

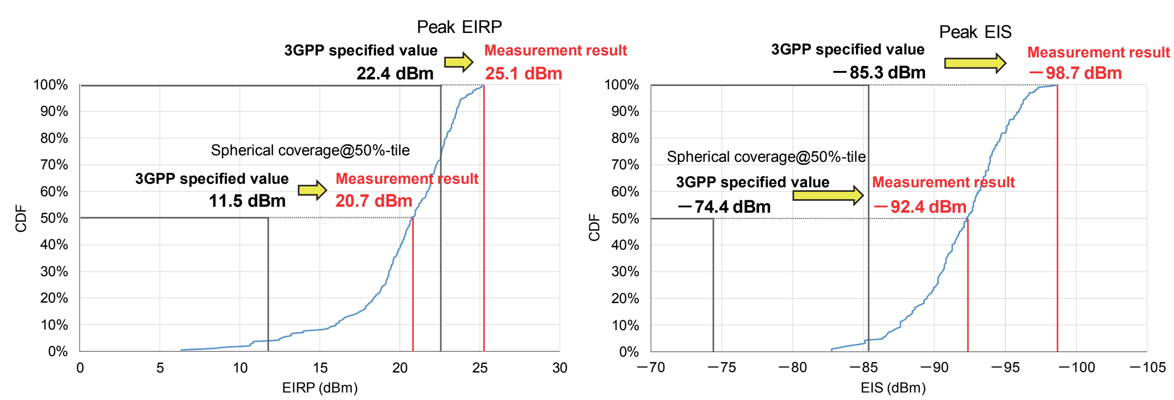

Figure 5 CDF measured value of EIRP and EIS

*24 Propagation loss: The amount of attenuation in the power of a signal emitted from a transmitting station until it arrives at a reception point.

*25 Antenna gain: A measure of the sharpness of antenna directivity usually expressed as the ratio of radiated power to that of an isotropic antenna.

*26 CDF: A function that represents the probability that a random variable will take on a value less than or equal to a certain value.

(3) Temperature rise standards for combined operations

The maximum temperature rise and rise rate under conditions of modeled usage scenarios that may be encountered by general users are set.

These standards have been mandatory for LTE-enabled mobile terminals, and have been set as a standard with 5G-enabled mobile terminal development to be followed when communicating.

5.3 5G Terminal Heat Generation

Power consumption tends to increase with 5G-enabled mobile terminals due to the many factors shown below.

- Increased number of parts to support mmW and wide frequencies
- Increased power consumption of the parts themselves due to improved communications speeds and CPU processing speeds
- Increased CPU load for applications specialized for services that greatly benefit from 5G communications, such as Augmented Reality (AR), Virtual Reality (VR) and high-quality video watching.

Increases in power consumption are accompanied by an increase in heat generation. To address this, expanding the surface area of the mobile terminal to dissipate and diffuse heat is an easy solution. However, it is not possible to endlessly enlarge 5G-enabled mobile terminals if excellent design is to be maintained.

5.4 Heat Countermeasures for 5G Terminals

To minimize heat generation while keeping the size compact, mobile terminals employ components with lower power consumption as well as advanced heat dissipation measures. In this section, we describe general and typical measures.

1) Addition of Heat Dissipating Elements (Hardware)

Heat sources in mobile terminals include CPUs, RF components for communications and power amplifiers[*27]. The structure is designed so that heat generated from these components is efficiently diffused to the surface of the mobile terminal (front, rear, frame) to dissipate it, and pastes and sheets are used as Thermal Interface Materials (TIM)[*28]. Compared to LTE-enabled mobile terminals, 5G-enabled mobile terminals utilize more heat dissipating elements.

2) Adoption of Vapor Chamber (Hardware)

Some models employ vapor chambers[*29] to more effectively diffuse heat from the aforementioned heat generation sources. The vapor chamber is a thin metal heat pipe[*30], a simple yet highly functional heat diffuser that absorbs heat from a heat source and emits it away. Heat pipes were also used in conventional LTE-enabled mobile terminals, but vapor chambers have become more widely used in 5G-enabled mobile terminals.

3) Application of Functional Limitations as Heat Control (Software)

Although these measures have been implemented, if the temperature exceeds the specified value during use, the performance of operating functions is limited to temporarily suppress the temperature rise.

---

*27 Power amplifier: A component that amplifies the signal output from a communication IC, and supplies it to the antenna.

*28 TIM: A highly thermally conductive substance used to efficiently dissipate the heat generated from components.

*29 Vapor chamber: A thermal diffuser that uses a heat pipe in the form of a plate to increase the amount of heat transferred.

*30 Heat pipe: A thermal diffuser for transferring heat from a heat source to another location. Heat pipes are often constructed like metal tubes with high thermal conductivity. The interior is under reduced pressure and contains a small amount of liquid, such as pure water. As one end is overheated, the liquid evaporates and moves to the other end and returns to a liquid state, thereby transferring heat.

By implementing these measures, 5G-enabled mobile terminals satisfy the aforementioned standards. In other words, even when various functions involving 5G communications are used, users can safely use mobile terminals.

6. The Broadening of Devices in the 5G Era

Leading up to the 5G era, various services and solutions have emerged that utilize features of 5G networks such as high speed, high capacity and low latency, as well as latest technologies including XR*31, AI, and big data.

However, current smartphones have not been able to use the full potential of these technologies due to constraints such as display size and performance of cameras, sensors, etc.

Therefore, in addition to the evolution of smartphones themselves, NTT DOCOMO proposes the "My Network Concept" to create cutting-edge services and solutions with partners, by strengthening the linkages between smartphones and peripheral devices.

To provide value by linking smartphones and peripheral devices, it is important to expand peripheral devices and develop environments where various peripheral devices can be easily used to realize experiences that cannot be provided by smartphones alone. We describe "Magic Leap 1*32" below as an example of realizing these requirements.

1) Overview of Magic Leap 1

Magic Leap 1 from Magic Leap is a light-weight, wide-angle wearable headset that utilizes spatial computing*33 to provide an interactive world that combines the real with the digital. Even without a monitor, seamless digital content can be projected and manipulated in real space.

When using game content in a residential living room, it is possible to blend the world of gaming with real rooms and furniture, giving the user an unprecedented immersive and interactive experience where characters pop out of walls or walk around on tables (**Figures 6** and **7**).

Figure 6 Interactive experience image (1)

*31 XR: A generic term for AR, VR, and Mixed Reality (MR), etc.

*32 Magic Leap 1: "MAGIC LEAP", "MAGIC LEAP 1", "LIGHTWEAR", "LIGHTPACK", the Magic Leap logo, and all other trademarks are trademarks of Magic Leap, Inc.

*33 Spatial computing: Technology that recognizes real-world objects and spaces, and fuses them with digital information. This technology allows us to overcome limitations of 2D displays and enables us to interact with the digital world in the same way as the real world, by combining the worlds together.

Magic Leap 1 includes high-performance displays and nine sensors, and is composed of Lightwear (the glass part) to achieve advanced space recognition and display capabilities, a pocket-sized Lightpack (the processor part) to achieve laptop-like performance with low power consumption, and Control (the controller part) that supports Six Degrees of Freedom (6DoF)*34 (**Figure 8**).

2) The Future Outlook

Amongst advanced users, it is common to use more than dozens of peripheral devices. On the other hand, there are many barriers to creating a world where all users can easily, safely and conveniently use peripheral devices.

Figure 7 Interactive experience image (2)

Figure 8 Magic Leap 1

*34 6DoF: Indicates the degree of freedom to move in three-dimensional space. Users can move their position forward/backward, left/right, up/down along 3 perpendicular axes, and rotate in relation to each axis. This allows users to identify their position in space, and content can be displayed in accordance with the user's movement.

For example, linking devices together requires many steps and is cumbersome. In addition, there is insufficient data to understand users in order to recommend devices or methods of use based on their hobbies, preferences, and literacy, and to help make the overall experience enjoyable.

To remove these barriers, NTT DOCOMO would like to contribute to the development of the entire industry by connecting device manufacturers with service providers, and to form a new ecosystem*35.

7. Conclusion

In this article, we described an overview of the 5G service-enabled terminals provided since March 2020, and details of efforts to realize 5G-enabled mobile terminals, such as radio component configuration and evaluation of it, and heat countermeasures.

Going forward, we will expand 5G-enabled models, enhance seamless linkage with peripheral devices, and provide advanced wireless technology so that a wider range of users can experience 5G-era terminals.

REFERENCES

[1] S. Nagata, et al.: "Technical Overview of the 3GPP Release 15 Standard," NTT DOCOMO Technical Journal, Vol. 20, No. 3, pp. 37-48, Jan. 2019.

[2] ISO13732-1: "2006 Ergonomics of the thermal environment - Methods for the assessment of human responses to contact with surfaces -," Oct. 2006.

[3] MCPC TR-023: "Mobile Device Safety Design Guidelines Version 1.00," Mobile Computing Promotion Consortium Technical Committee, Apr. 2016 (In Japanese).

*35 Ecosystem: A symbiotic mechanism in which various businesses partner up, utilize each other's technologies and assets, and engage with society to create a series of processes from research and development through to sales, advertising and consumption.