**UNWANTED EMISSIONS IN THE SPURIOUS DOMAIN FROM WIRELESS POWER TRANSFER FOR ELECTRIC VEHICLES ON FREQUENCIES ALLOCATED TO THE AMATEUR SERVICE**

## 1 Summary

This document sets out the challenges associated with the deployment of WPT(EV) in urban/suburban residential environments insofar as coexistence with stations in the amateur service operating in the same environment is concerned. The same concerns also apply to broadcast services.

## 2 Background

The amateur service is a radio service defined in the ITU Radio Regulations. There are up to 3 million licensed amateur radio operators around the world. ITU Radio Regulations set out the frequencies allocated to the amateur service. Although allocations vary slightly between ITU Regions, the following table provides a general overview of current allocations at frequencies below 30MHz.

| **Frequency range** | **Allocation status** |
|---|---|
| 135.7 - 137.8 kHz | Secondary allocation |
| 472.0 - 479.0 kHz | Secondary allocation |
| 1.8-2.0 MHz | Part primary, part secondary |
| 3.5-4.0 MHz | Primary allocation |
| 5,351.5-5,366.5 kHz | Secondary allocation |
| 7.0-7.3 MHz | Primary allocation |
| 10.1 - 10.15 MHz | Secondary allocation |
| 14.0-14.35 MHz | Primary allocation |
| 18.068-18.168 MHz | Primary allocation |
| 21.0 - 21.45 MHz | Primary allocation |
| 24.890 - 24.990 MHz | Primary allocation |
| 28.0 - 29.7 MHz | Primary allocation |

*Table 1:ITU Allocation to the Amateur Service in the ITU Radio Regulations*

The characteristics of stations operating in the amateur service are set out in Recommendation ITU-R M.1732-2 - *Characteristics of systems operating in the amateur and amateur-satellite services for use in sharing studies.* The amateur service is a small signal service, relying on maintenance of low noise levels on the short-wave spectrum.

Report ITU-R SM.2158 includes a definition of appropriate protection ratios for the amateur service and forms the basis of the protection built in to the standards for domestic PLT systems through the application of notches to achieve a proposed maximum 0.5 dB increase in background noise.

The Radio Regulations define the amateur service as:

> «**1.56** *amateur service:* A *radiocommunication service* for the purpose of self-training, intercommunication and technical investigations carried out by amateurs, that is, by duly authorized persons interested in radio technique solely with a personal aim and without pecuniary interest.
>
> **1.57** *amateur-satellite service*: A *radiocommunication service* using *space stations* on *earth satellites* for the same purposes as those of the *amateur service*.»

The maximum permitted transmitter power is dependent on national regulations, varying from around 100 W to 1.5 kW output power. While some countries authorize relatively high transmitter power many amateur operators choose to operate using low transmit powers in the order of a few watts. A wide variety of antennas and equipment, depending on location and financial means is used. Consequently, there is no standard amateur radio station.

Users of the amateur services do not generally have the opportunity to position antennas far away from electrical wiring. They must install their antennas within the boundaries of their homes and properties, which generally means in close proximity to power mains and telephone wiring both within their own property and adjacent properties. Other sources of localized interference can be minimized by the amateur choosing not to use equipment such as luminaires, switch-mode power supplies, and other equipment generating interference when operating. That choice is not available in the case of many cable-borne data transmission systems, where the emissions are present all the time.

Amateur radio stations communicate over long distances on the HF bands, making optimum use of propagation windows. Amateurs frequently operate at or near to the minimum signal-to-noise ratio for effective communication. Limits of communication are generally determined by the received signal strength in relation to the background noise. Radio amateurs manage to communicate effectively with a signal-to-noise ratio of some 6 dB for voice communications in a nominal 2.4 kHz bandwidth and as low as minus 6 dB (related to the same bandwidth) for Morse code or spectrum-efficient data modes.

Many users of the amateur services provide disaster relief communications. In many countries, amateur radio is seen as a valuable back-up service in case of breakdown or overload of normal communications systems. Governments rely on this capability at times of emergency. Amateur service HF and VHF allocations are used for this purpose.

## 3 Operational characteristics

Amateur stations and amateur-satellite earth stations generally do not have assigned frequencies but dynamically select frequencies within an allocated band using listen-before-talk (LBT) techniques. Terrestrial repeaters, digital relay stations and amateur satellites use frequencies selected on the basis of voluntary coordination within the amateur services. Some amateur frequency allocations are exclusive to the amateur and amateur-satellite services. Many of the allocations are shared with other radio services and amateur operators are aware of the sharing limitations.

Operating protocols vary according to communications requirements and propagation. MF and HF bands are used for near-vertical-incidence-sky wave (NVIS) to global paths. VHF, UHF and SHF bands are used for short-range communications. Amateur satellites afford an opportunity to use frequencies above HF for long-distance communications.

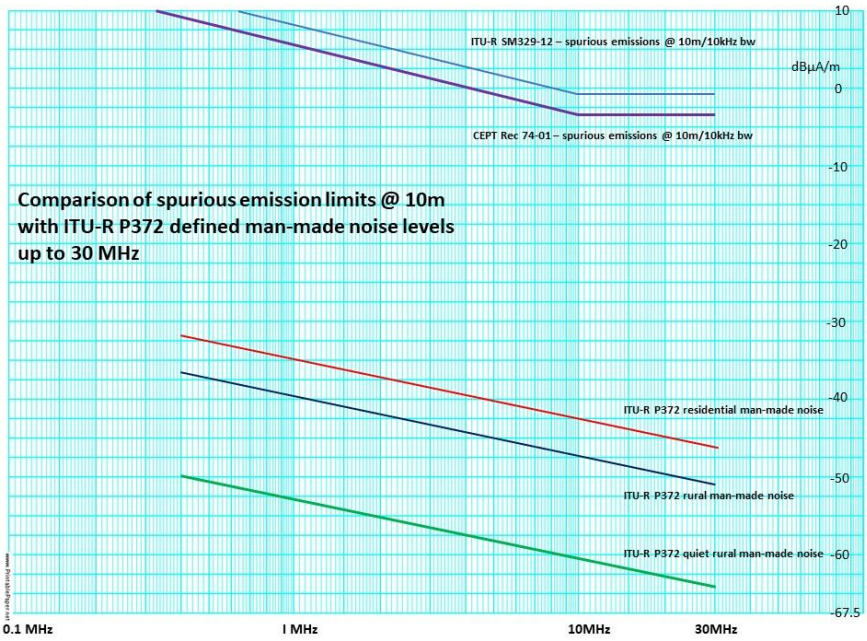
## 4 The Amateur Service and Wireless Power Transmission for Electric Vehicles (WPT(EV))

Wireless power transmission for electric vehicles (WPT(EV)), is a technology which is intended to permit the charging of electric vehicles at home (and elsewhere) using induction coupling from a charging "pad" on the floor under the vehicle without the need to plug the vehicle into a charging point. Whilst the technology is still under development, some installations for public service vehicles (buses) are already in operation, using charging frequencies around 20 kHz. Discussions are under way in CEPT, CISPR and ITU over the introduction of Wireless Power Transmission for Electric Vehicles on a widespread basis across Europe. Domestic charging systems are expected to use a frequency around 85kHz. **This poses a real risk to radio communications in the urban/suburban/ rural environment arising from the harmonics from these high power installations.**

Existing spurious emission limits were developed with a degree of discounting because of the probability of co-location of emitter and receiver, duty cycle of the emitter and whether the frequency of emission coincided with the receiver frequency. In the case of WPT(EV) these factors do not apply because of:

- The projected density of deployment of WPT(EV) – 5 units per hectare, meaning that a WPT(EV) installation could be within 20m of every property
- The duty cycle of WPT(EV) – charging times of 6-12 hours have been quoted
- The rich harmonic content of the WPT(EV) installation

CEPT intends to classify WPT(EV) as a "Short Range Device" – a low power device where ***no harmful interference may be caused to any radio communications service***. Yet it is clear that this is far from the case, as the chart below shows.




This chart compares the ITU-R P372 background noise levels with the limits defined in CEPT 74-01 and ITU-R SM329 for emissions in the spurious domain. The latter measurements are at 10m from the source. It is clear that if WPT(EV) simply complies with the CEPT or ITU limits, this will have the effect of degrading the noise level at harmonic frequencies of the WPT(EV) by some 50-60 dB leading to a significant increase in the instances of harmful interference to radiocommunication service. It is not yet clear what the actual spurious performance of WPT(EV) will be, but it is clear that to provide adequate protection to radio services (broadcast, amateur and others) in the residential environment, the existing limits will need to be tightened very significantly.

As stated above, these existing spurious emission limits, when first developed, were relaxed to take account of the probabilities of

- a device emitting an unwanted emission in the spurious domain coincident with the frequency of operation of a victim receiver
- the emission being physically relatively close to the victim receiver
- the emission being of short duration
- short range devices being low power devices

Now that high power, high duty cycle and potentially wideband emissions are planned for the residential environment, with high density of deployment, it follows that the existing limits are no longer viable.

The degree to which the limits need to be improved will depend on the nature of the WPT(EV) signal. If it is possible to assign a single frequency on which all WPT(EV) systems operate, and to maintain a high degree of tolerance to that frequency, coupled with good phase and wideband noise from the WPT(EV) emissions, then the degree of improvement in the spurious emissions limit is less than if the WPT(EV) signal operates within a range of frequencies and/or has poor wideband noise performance.

**Summary**

We seek the support of administrations to ensure that spurious emission limits are set for WPT(EV) which will protect incumbent radio services in the urban/suburban residential environment. We ask administrations for form a view on this technology and to make their views known to CEPT and to play an active part in the discussions in CEPT SE24 on this matter. We are happy to offer further input if requested.

International Amateur Radio Union

March 2018