Demonstrating 'EMF compliance' for RF electromagnetic fields

FIGURE 1: Front sheet of RSGB EMF Calculator.

Most UK amateurs will already be fully compliant with ICNIRP requirements. As this series continues, the RSGB will help you to demonstrate that for your own station.

Ofcom is introducing new licence regulations requiring ***all*** amateurs [1] to comply with international guidelines for limiting exposure to RF electromagnetic fields (EMF) [2]. Ofcom has also published a guidance document for all licensees, along with more specific guidance for amateurs [3, 4].

For background to this change, see part 1 of this series in March *RadCom*, and the accompanying article online [5, 6]. New amateur licence conditions will come into effect from May 2021 that include a new Schedule specifically for EMF compliance.

Ofcom has taken a staged approach that allows for assessments to be completed by November 2021 for frequencies above 10MHz, and by May 2022 for frequencies below 10MHz. This staged introduction is to allow new assessment methods to be developed, especially for frequencies below 10MHz. Anticipating the need for guidance about these lower frequencies, the RSGB/ARRL EMF team [5] has already been working on the problem, and in this article we show some new options for demonstrating compliance on the bands between 1.8 and 7.1MHz.

The **assessment process** is essentially the same on all bands:

1. Define the specific configuration that you are assessing: frequency band, RF power, mode and Tx/Rx cycles, type and location of antenna, and any other details relevant for the assessment.
2. Estimate **exclusion zones** where people might be exposed above the relevant limit.
3. If you have identified exclusion zones but can be sure that members of the general public cannot access these zones by normal practical means (eg, if the zone is on the roof) then you have demonstrated compliance. If they could gain access, then include a practical plan to manage that situation – see "Managing Exclusion Zones" later.
4. Keep all the above as your compliance assessment record.

Repeat 1-4 for each different operational configuration that needs to be assessed. For example, a different frequency band, a different antenna or a higher power level, or a change of mode – all of these will change your EM fields and will need a new assessment. You may be able to save some work by assessing the most demanding configurations first. For example, if you are compliant at the highest power level that you plan to use, there is no need to assess that same case at lower power levels

Your assessment options

Ofcom guidance offers several options for making an assessment [3, 4]. Feel free to use any of them (or any combination) to assess your compliance.

Low power: If the radio equipment never transmits above 10W EIRP, the assessment can be as simple as recording that fact. You can often use the RSGB EMF Calculator (see below) for confirmation.

Manufacturer's instructions: If the manufacturer of the radio equipment (transmitter and antenna) has provided instructions to ensure that the equipment complies with ICNIRP guidelines, then you can demonstrate compliance by following those instructions. This will apply mostly to low-power hand-held radios that are supplied complete with an antenna.

RSGB EMF Calculator: RSGB is providing a calculator that covers the most important parts of assessing and recording compliance. It provides information that can then be used to define exclusion zones where people should not be present while you are transmitting. If no-one is present in the exclusion zone while you are transmitting (or if no-one could reasonably be expected to be) then compliance has been demonstrated.

Other EMF calculations: Ofcom is providing a calculator that is based on ICNIRP 1998 limits [7]. Ofcom will also accept results from

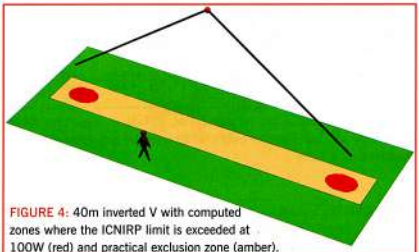

FIGURE 4: 40m inverted V with computed zones where the ICNIRP limit is exceeded at 100W (red) and practical exclusion zone (amber).

inaccessible, or if access is limited in some other reliable way – then you will have demonstrated compliance.

First look at pre-assessed configurations

The following examples are for operations below 10MHz that are not covered in the Ofcom calculator, and give you a first look at using pre-assessed station configurations to deliver a quick – and positive – assessment result. Details are in RSGB Technical Note PAC-1, *EMF Compliance Assessment of Low-band Half-wave Dipoles*, to be published online [6, 9].

Example 1 – 80m home station: This example shows how a simple 80m station can be demonstrated to be compliant at power levels up to 400W without the need to change anything. **Figure 2** shows our test case, a half-wave dipole for 80m in a suburban garden. Details matter in EMF assessment, and all the following will prove important. At the house end, the dipole is at 6m above ground level (AGL), attached via an insulated extension 2.5m long. The far end of the dipole is 7m AGL with a similar insulated extension. The centre of the dipole sags to 5.5m AGL due to the attached coaxial feedline (not shown). The feedline drops vertically to ground and has common-mode chokes to reduce feedline radiation. Ground characteristics are unknown, except that this location is not beside the sea. RF power level could be anything up to 400W PEP, using any licensed transmission mode.

Because some of the above information is fuzzy (and in real-life assessments, is always likely to be) the data tables in PAC-1 allow you to specify the values that you do know, while choosing 'Any value' for those that you don't. We are not certain about the V-angle of the dipole, so for the moment let's assume 'Any angle' for that one. For the ground type we can choose 'Any (excluding Sea)'.

That input information leads us to Table 2 in PAC-1, and **Figure 3** shows the relevant extract. The input assumptions are highlighted in blue, and the conclusion "the minimum antenna height to remain compliant is 5.3 metres" is highlighted in red. Other constraints are set out in PAC-1, notably that precautions must be taken to suppress feedline radiation and that a horizontal clearance of at least 2.0m beyond the ends of the dipole is also required.

Since our example case meets all these conditions, and no part of the dipole is lower than 5.5m above ground, this station configuration can be declared compliant up to 400W PEP, full carrier. No further EMF precautions are required, except to ensure that all the assumed conditions continue to be met. Record that this configuration is based on 'PAC-1, Table 2, case #1' and the job's done.

Example 2 – 40m inverted-V dipole for portable operation: This example uses another pre-assessed configuration from PAC-1, this time in a portable situation where compliance with the EMF licence condition is not automatic. The key point here will be that you can still demonstrate compliance by knowing where your ground-level exclusion zone is, and not transmitting if anyone ventures into that zone.

Figure 4 shows the antenna configuration. There is a central insulated mast (not shown) with the ends of the sloping wires attached to ground stakes via insulated cord (not shown). The mast height is 8m but the ends of the dipole will be only 2.0m AGL, forming a distinct inverted-V. RF power may be up to 100W, and we make the same assumptions as for Example 1 about avoiding feeder radiation.

Compliance here is obviously not automatic because the ends of the dipole are barely above head height. Figure 4 shows in red where the computed EMF at an RF power level of 100W would exceed the relevant ICNIRP limit for someone standing at ground level. These zones are quite small, but their precise shape and size will vary with V angle, RF power and other unknown conditions such as ground conductivity. For practical access management, a much simpler exclusion zone is therefore defined as the complete strip of land beneath the dipole, coloured amber in Figure 4. If operating /P on public land, you would need to be watching that area anyway for conventional safety reasons, so the only addition for EMF compliance is not to transmit if anyone should enter.

For 100W on 40m, PAC-1 suggests the strip should be 2.2m wide, with a 1.1m extension beyond each end of the dipole. That estimate is for "Any ground conditions (excluding Sea)" so it will remain valid for most future portable operations with that antenna. There is no need to over-complicate the situation with precise measurements, barriers or signage – all that's needed is to maintain awareness while you are operating.

Conclusions

There are many practical ways to demonstrate compliance with the new Ofcom EMF licence conditions – most amateur operations **already do comply**. The RSGB will be following up the technical work with online templates and examples for the necessary records to help you demonstrate compliance.

The RSGB/ARRL EMF team are currently working on many different station configurations including HF/VHF/UHF Yagis, general wire antennas, verticals, and others.

There is no need to feel under pressure about this. We have until at least November 2021 to do assessments for frequencies above 10MHz, and until May 2022 for the lower frequencies. In the meantime, please continue to follow the RSGB EMF pages online [6] for longer articles and more detail.

Notes and references

[1] Since no amateur licence is restricted to "10W EIRP", we all need to record how we comply with this new condition. (Read the wording of reference 2 carefully.).

[2] Ofcom, Implementation of measures to require compliance with international guidelines for limiting exposure to electromagnetic fields (EMF), 1 March 2021. www.ofcom.org.uk/manage-your-licence/emf.

[3] Ofcom, Guidance on EMF Compliance and Enforcement, 1 March 2021. www.ofcom.org.uk/__data/assets/pdf_file/0025/214459/guidance-emf-compliance-enforcement.pdf.

[4] Ofcom, Ofcom's new EMF licence condition: what you need to know as an amateur radio licensee, 11 March 2021. www.ofcom.org.uk/__data/assets/pdf_file/0026/215657/What-you-need-to-know-as-an-amateur-radio-licensee-Draft-version.pdf.

[5] RSGB/ARRL EMF Team, New licence regulations for RF electromagnetic fields, *RadCom* March 2012, pages 22-24.

[6] All RSGB online publications about EMF compliance (and easy links to relevant Ofcom publications) can be found at www.rsgb.org/emf. Do not use any publication marked 'Preliminary' for your formal compliance assessment, but follow the RSGB EMF pages for updates.

[7] Ofcom initially accepts the use of either the old ICNIRP 1998 or the ICNIRP 2020 recommendations reflecting the most up-to-date science. RSGB guidance is based on ICNIRP 2020 so that we won't need to update.

[8] Pre-assessed configurations developed by RSGB are recognised by Ofcom as a basis for amateurs to demonstrate compliance.

[9] Below 10MHz, the constraining ICNIRP 2020 limits are based on 'peak' field strengths at any moment during the transmission, so power reduction factors based on mode and transmit-percentage must not be applied in that frequency range. ICNIRP uses the word 'peak' in a very similar way to "Peak Envelope Power" (as defined on page 20 of your licence).

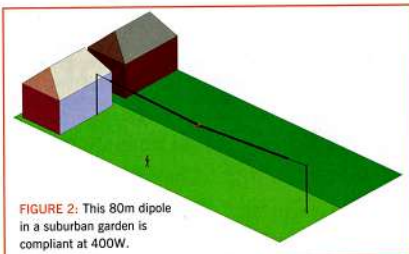

FIGURE 2: This 80m dipole in a suburban garden is compliant at 400W.

established computer programs provided you can demonstrate that they give valid results for comparison against ICNIRP limits. Amateurs who are experienced in antenna modelling may be able to use this latter option to estimate exposure for comparison with the relevant ICNIRP limits, and thus to define three-dimensional exclusion zones.

Pre-assessed station configurations: The RSGB is developing a library of pre-assessed configurations for amateur stations, with guidance to help you to demonstrate compliance [7]. We are doing a mass of detailed work using advanced computation techniques, so that you don't have to. If your station configuration matches one of these pre-assessed cases (or can be made to do so, including any stated precautions) then you can demonstrate compliance. The RSGB will also be using the detailed data from the pre-assessed configurations to develop simple guidelines such as: "If your 144MHz Yagi is more than *x* metres above ground, you will be compliant up to RF power levels of *y* watts PEP (subject to a few other conditions)". If you can meet the relevant conditions, this may be the easiest way to establish compliance.

Managing Exclusion Zones

Output from all of the calculation methods will indicate locations where a person could be exposed to EMF above the relevant ICNIRP limit. These are then used to define **exclusion zones**.

ICNIRP EMF limits are about the exposure of **people** to EM fields. **Whenever no person is present within the exclusion zone, that in itself is sufficient to establish compliance.**

To demonstrate compliance with the EMF license conditions you will have determined where your exclusion zone boundaries are, and how you can be sure that no-one is present within them when transmission is taking place – for example, if those boundaries are physically inaccessible, or if access is limited in some other reliable way, or you ensure that you don't transmit when a person is within the zone.

The simplest type of exclusion zone is defined by the minimum distance from the antenna in any direction. When this minimum distance is based on the worst-case direction, that value will be over-cautious for other directions. If that overestimate causes no difficulty in your particular situation, then by all means use the simplified calculation. But don't forget that more advanced methods can map the field strengths much more accurately in 3D, and so give a more reliable indication of the size and the shape of the exclusion zone boundaries (see Figure 4, for example).

If you do need to operate an exclusion zone, remember that licensed amateurs have an almost unique advantage over other radio services: there is almost always a trained operator on-site who can exercise real-time supervision of the exclusion zone. Whenever necessary, be sure to include this in your compliance plan.

#	Configuration Description: Ground	V angle	Transmit power	Minimum height AGL (any part of radiating structure): 160m	80m	60m	40m
1	Any (excluding Sea)	Any	Up to 10 W	2.3m	2.3m	2.3m	2.3m
			Up to 50 W	3.2m	3.0m	2.9m	2.8m
			Up to 100 W	3.7m	3.6m	3.4m	3.3m
			Up to 400 W	6.4m	5.3m	N/A	4.3m

FIGURE 3: Extract from Technical Note PAC-1, Table 2. Input assumptions are in blue, and the minimum height for 80m for this pre-assessed configuration is 5.3m.

Measurement: Ofcom also includes on-site EMF measurement as a means of demonstrating compliance; but accurate measurements are far more difficult than most amateurs imagine. They need to follow strict engineering standards and require calibrated test equipment – all of which makes on-site measurement challenging.

The rest of this article will give some practical examples of how you can use the RSGB Calculator and/or the pre-assessed configurations to establish compliance and manage exclusion zones – see sidebar.

Introduction to the RSGB EMF Calculator

You can download the RSGB EMF Calculator and a video demonstrating its use from www.rsgb.org/emf. You can use the calculator to analyse your station configuration to determine:

- the average and peak power from your transmitter for your stated usage
- the power delivered to the antenna, which can also be used with other EMF calculation tools
- the peak and 6 min time-averaged EIRP, which can be used to demonstrate compliance – see Low Power previously
- the required separation between the antenna and any exposed person (the Ofcom "compliance distance"), which is then used to determine exclusion zones

Figure 1 shows the front sheet of the RSGB EMF Calculator, with the yellow shaded cells defining where input is required. When you have completed the assessment, save or print the worksheet as your record.

The first column in Figure 1 defines your **Radio Setup**: the frequency band, transmission mode, RF power and percentage of transmitting time within a 6-minute averaging period. Many of these values come from drop-down lists that appear when you click in the cell, or you can always enter your own custom values. In the **Feeder** column you can select the cable type and length, and any other losses that affect the power delivered from the feeder into the antenna. Outputs available from this column are the average and the peak power delivered to the antenna. In the right column you can select the antenna type, height, and an optional directivity factor (see video for details).

The calculated average and peak EIRP are then shown at the bottom of the right-hand column. You can see in the example shown that even "50W to a dipole" using processed SSB can meet the 'low power exemption' on 14MHz because the time-averaged EIRP is less than 10W. However, the calculator will also indicate other combinations of power and mode that could not claim this exemption (eg 50W on some data modes).

The calculator determines a compliance distance (see graphic in **Figure 1**) between the antenna and any exposed person [2-4]. That information can be used to define the **exclusion zone** (see sidebar) if the calculated EIRP is greater than 10W. If you can be sure that no-one will be present within that zone when transmission is taking place – for example, if it is physically

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