



Birmingham Eastside Extension

ES Volume 2 Technical Appendix V:
Electromagnetic Fields Technical Information

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1 Electromagnetic Fields

1.1 Background

1.1.1 This technical appendix should be read in conjunction with ES Volume 1 Main Statement Chapter 19: Electromagnetic Fields.

1.1.2 Electric and magnetic fields are produced wherever electricity is used. The electric field is produced by voltage and the magnetic field by current. Electromagnetic fields (EMF) cause two types of effect:

- interference to third party electric and electronic equipment. This is called electromagnetic interference (EMI) and is the disturbance that affects an electrical system due to magnetic and electric fields, electromagnetic induction or electromagnetic radiation emitted from an external source. Electromagnetic Compatibility (EMC) is where the EMI is controlled to allow all the equipment's working in an environment to operate without interfering with each other; and
- the potential to cause harmful effects in the human body.

1.2 Legislation

European Directives

1.2.1 The following European Directives are applicable to EMF and EMC on the BEE:

- EMC Directive (2014/30/EU) replacing 2004/108/EC;
- EMF Directive (2013/35/EU);
- Machinery Directive (2006/42/EC);
- Procedure for the provision of information in the field of technical standards and regulations (98/34/EC); and
- Active Implantable Medical Devices Directive 90/385/EEC.

Harmonised EMC Standards

1.2.2 Harmonised standards are technical specifications adopted by a recognised European Standardisation body under a mandate from the European Commission in conformity with the procedures laid down in European Directive 98/34/EC. A list of harmonised standards is published by the Commission in the Official Journal (OJ) of the European Union for each Directive.

1.2.3 For railway and tram systems compliance with the EMC Directive can be demonstrated by applying the requirements of the harmonised railway EMC standards:

- BSEN 50121-1:2015. Railway Applications. EMC. General;
- BSEN 50121-2:2015. Railway Applications. EMC. Emissions of the whole railway system to the outside world;

- BSEN 50121-3-1:2015. Railway Applications. EMC. Rolling Stock. Train and complete vehicle;
- BSEN 50121-3-2:2015. Railway Applications. EMC. Rolling Stock. Apparatus;
- BSEN 50121-4:2015. Railway Applications. EMC. Emissions and immunity of the telecommunication apparatus; and
- BSEN 50121-5:2015. Railway Applications. EMC. Emission and Immunity of fixed power supply installations and apparatus.

Standards Harmonised under Implantable Medical Devices Directive (90/385/EEC)

- BS EN 45502-2-1 Active implantable medical devices. Particular requirements for active implantable medical devices intended to treat brad arrhythmia (cardiac pacemakers).

Other European Standards

- 1.2.4 The following European Standards are applicable to EMF and EMC on the BEE:
- BS EN 50500:2008+A1:2015 Measurement procedures of magnetic field levels generated by electronic and electrical apparatus in the railway environment with respect to human exposure (References BS EN 45502-2-1 for levels).

International Standards

- 1.2.5 The following International Standards are applicable to EMF and EMC on the BEE:
- ICNIRP Guidelines for limiting exposure to time-varying Electric, Magnetic, and Electromagnetic fields (Up to 300 GHz). Health Physics 74(4):494-522;1998; and
 - ICNIRP Guidelines for limiting exposure to Static Magnetic Fields. Health Physics 96(4):504-514;2009.

UK policy

- 1.2.6 The EMC Directive 2004/108/EC is implemented into UK law by Statutory Instrument (SI) 2006 No. 3418. The new EMC Directive 2014/30/EU came into force on the 20 April 2016 without any transitional period. The UK implementation of the new EMC Directive is currently in progress.
- 1.2.7 The EMF Directive is to be implemented into UK law by 1 July 2016.
- 1.2.8 Network Rail policy BS EN 50121 (Parts 1-5):2015 sets limits for radio frequency interference (RFI) emissions and immunity. However, they do not contain limits for every possible frequency employed by equipment which may be installed on the railway or adjacent to it. To address these issues Network Rail have developed their own EMC procedures to ensure their assets do not suffer from or produce excessive EMI outside the limits stipulated in BS EN 50121. Where the BEE crosses or runs parallel to Network Rail Infrastructure due consideration of NR standards has to be given, see section 1.4

- 1.2.9 Network Rail detail their EMC Strategy and assurance process in the following documents:
- EMC Strategy for Network Rail (NR/L1/RSE/30040); and
 - EMC Assurance Process (NR/L2/RSE/30041).

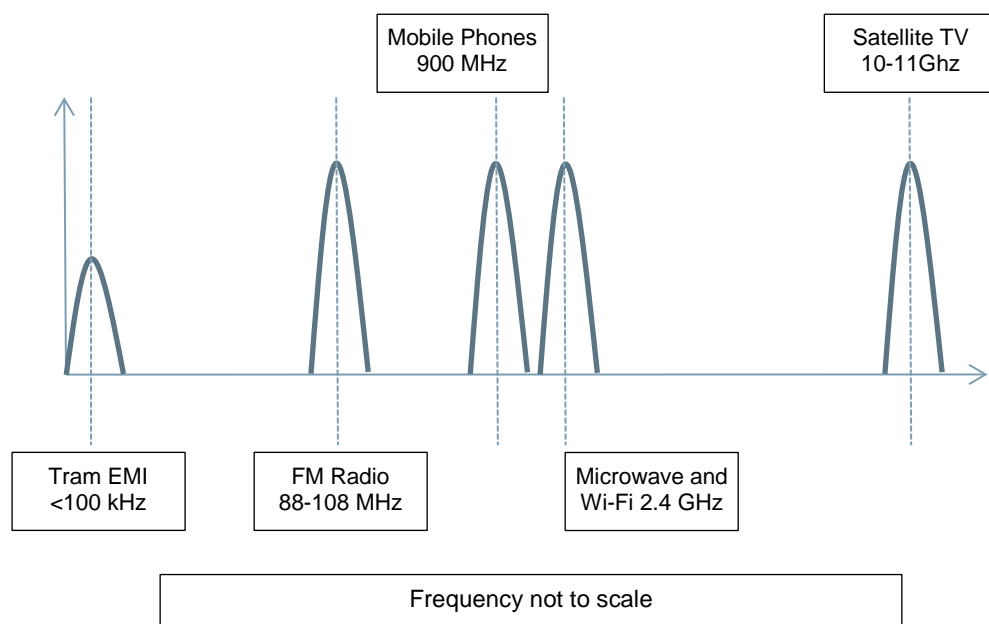
1.2.10 For the protection of their assets on the railway Network Rail has produced a series of documents (formerly called IDI documents) setting out the methodology for proving compatibility, see section 1.4.

1.3 EMC/EMF BEE Design

EMI sources

- 1.3.1 The most significant source of EMI generated by the BEE is considered to be the direct current (DC) and very low frequency magnetic fields that are generated by the traction current flowing through the overhead wires due to tram movement and battery charging. The amount of traction current flowing in the system will depend on the quantity of power required by the trams which in turn depends upon their mass, the required acceleration, number of passengers and the gradient of the route. The majority of the BEE route is on street or passes through pedestrianised areas and therefore operates at low speed with correspondingly low acceleration. The BEE route will therefore produce much lower magnetic fields than those found on the existing Midland Metro Line 1 which runs on segregated track at high speed.
- 1.3.2 Radio frequency EMI will also be generated by the BEE system from the on board traction power converters, battery charger and radio communications systems. The majority of the EMI is low frequency well away from the frequencies utilised by common radio devices, see Figure 1.1.

Figure 1.1: Frequency spectrum separation



Source: Mott Macdonald, 2016

- 1.3.3 The metallic mass of the tram, combined with the traction power DC magnetic field, may locally modify the earth's static magnetic field as it moves past a sensitive receptor (fixed installation). The resulting momentary shift or perturbation in the Earth's magnetic field creates a "Quasi" or "slowly-varying" DC field.
- 1.3.4 If the tram current pantograph makes intermittent contact with the overhead wires, electrical arcing may result leading to the generation of broadband EMI. This type of interference has the ability to affect radio transmissions and very sensitive equipment.
- 1.3.5 The BEE traction power supply may produce conducted EMI (e.g. harmonics) that may affect the quality of the distribution network operators (DNO) power supply. Birmingham DNO is currently Western Power Distribution.
- 1.3.6 As the BEE will operate from a DC current supply, there is the potential for stray DC current to occur. This is defined as part of the current caused by a DC traction system which follows paths other than the return circuit (running rails). This can have two main effects:
- Corrosion due to stray DC current. This occurs when the return DC current from the traction power converter flows in an unintended path back to source such as metal structures and buried pipe work. When this occurs, structural damage and deterioration of

buried services may occur. To prevent stray current issues the rail resistance has to be kept as low as possible, so that the current is retained in the rail, and the rail must be insulated from earth sufficiently to stop stray current leaving the rail; and

- Interference to Network Rail train detection systems e.g. DC track circuits. This occurs when the return DC current from the traction power converter flows in an unintended path back to source such as Network Rail running rails. When this occurs, there is a risk of degrading the operation of the DC track circuits. At worst, it may have safety implications.

EMI victim systems

- 1.3.7 The type of equipment most susceptible to DC and very low frequency magnetic EMI tends to be devices that rely upon the scanning of an electron beam e.g. electron microscope; but also devices that operate at low frequencies (e.g. audio equipment) and other devices that measure very small, low frequency signals such as those performed in physiological measurement (e.g. electroencephalogram (EEG) and electrocardiogram (ECG)), although other items of equipment such as magnetic resonance imaging (MRI) scanners and hospital based linear accelerators (x-ray imaging devices) may also be susceptible to the effects from external low frequency magnetic fields.
- 1.3.8 Radio frequency interference may affect the operation of high frequency systems such as telecommunication systems and MRI scanners.
- 1.3.9 "Quasi" or "slowly-varying" DC fields may affect the stability and accuracy of sensitive instruments.
- 1.3.10 Harmonic emissions conducted back into the electricity distribution system may affect other items of electrical equipment connected to the power distribution network.

1.4 Management of EMC

- 1.4.1 For large civil engineering construction projects of this type there is a well-established process for managing and controlling EMC and limiting impacts to EMI victim systems. The project EMC manager shall ensure that good EMC engineering practice is applied on the project (e.g. equipment selection, cable routing, interfaces etc) by producing project specific guidance in the following documents:
- an EMC Management Plan will be prepared at the onset of the detailed design phase setting out the overall strategy for the project, this will consider the route and interfaces with 3rd parties such as NR;
 - during detailed design an EMC Control Plan is produced providing guidance on good EMC engineering practice to be adopted by the designers. At this stage a hazard log is produced listing all EMC hazards associated with BEE and a qualitative risk assessment carried out;

- during construction the EMC Control Plan is developed further to ensure adoption of good EMC engineering practice to the siting of equipment and installation of cables; and
- during the BEE trials phase testing will be carried out to measure the DC and low frequency magnetic fields and radio frequency electromagnetic fields produced by the BEE. A report will be produced containing all measured data for analysis.

1.4.2 All of the documents and reports mentioned above will form part of an overall EMC Technical File for the BEE which will form the evidence of compliance with the essential requirements of the EMC Directive 2014/30/EU.