LONDON-WEST MIDLANDS ENVIRONMENTAL STATEMENT

Volume 5 | Technical Appendices

EMI supporting information (EM-002-000)

EMI

November 2013

VOL 5

ES 3.5.0.7.2

LONDON-
WEST MIDLANDS
ENVIRONMENTAL
STATEMENT

Volume 5 | Technical Appendices

EMI supporting information (EM-002-000)

EMI

November 2013

ES 3.5.0.7.2

Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

A report prepared for High Speed Two (HS2) Limited.

High Speed Two (HS2) Limited,
Eland House,
Bressenden Place,
London SW1E 5DU

Details of how to obtain further copies are available from HS2 Ltd.

Telephone: 020 7944 4908

General email enquiries: HS2enquiries@hs2.org.uk

Website: www.hs2.org.uk

High Speed Two (HS2) Limited has actively considered the needs of blind and partially sighted people in accessing this document. The text will be made available in full on the HS2 website. The text may be freely downloaded and translated by individuals or organisations for conversion into other accessible formats. If you have other needs in this regard please contact High Speed Two (HS2) Limited.

recycle

Printed in Great Britain on paper containing at least 75% recycled fibre.

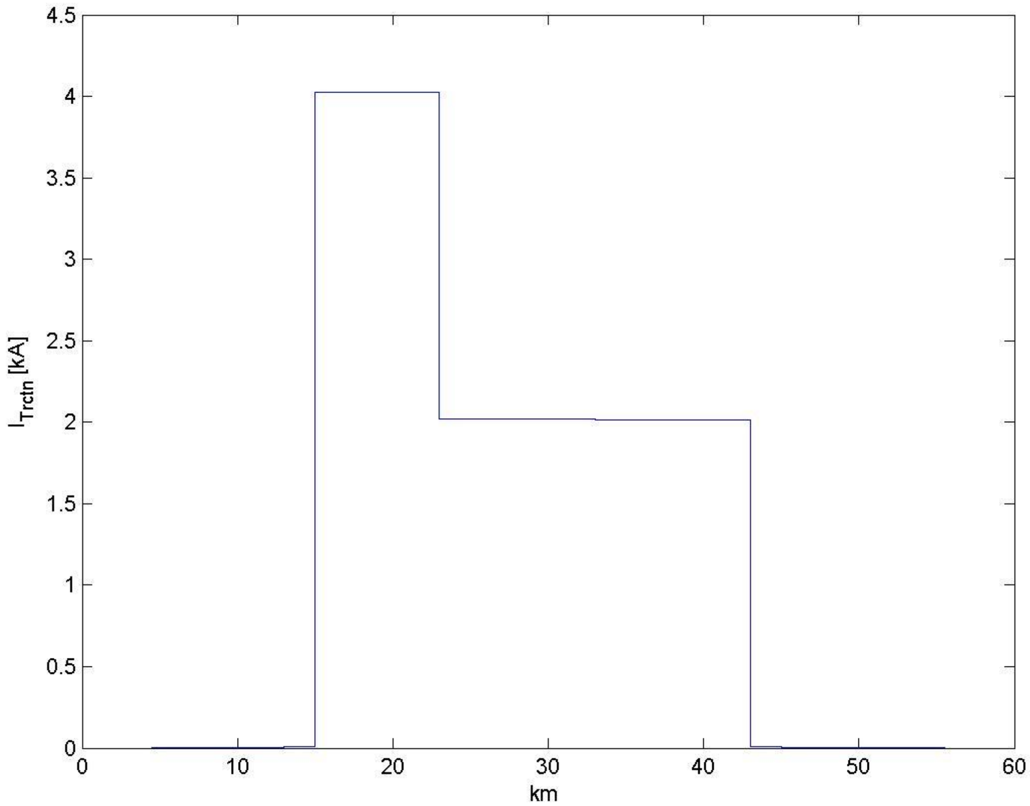
Contents

1 Flux density field levels

1.1.1 For an initial assessment of the magnetic field levels and the induced voltages along the HS2 route, a notional / fictive feeding section has been modelled for computer simulation. The resulting feeder station load corresponds to the highest load, as derived from the original multi-train traction power simulation prior to the initial preliminary design stage. The express feeder cables, as their need at that stage had yet to be established, have not been taken into account. Please note that the results present initial levels of magnetic fields and induced voltages. More accurate results will be produced in future simulations based on refined computer models.

1.1.2 In the mathematical model for the field and inductive voltage calculations a feeder station is placed at km 15 (Figure A2.1). Traction loads with a current of about 1000 A and a power factor of 0.95 are inserted on each track at km 22.5 and km 42.5 (Figure A2.1). For the distance between the traction loads 20 km has been selected on the basis of a headway of 18km, which corresponds to a three minute interval between consecutive trains at 360kph.

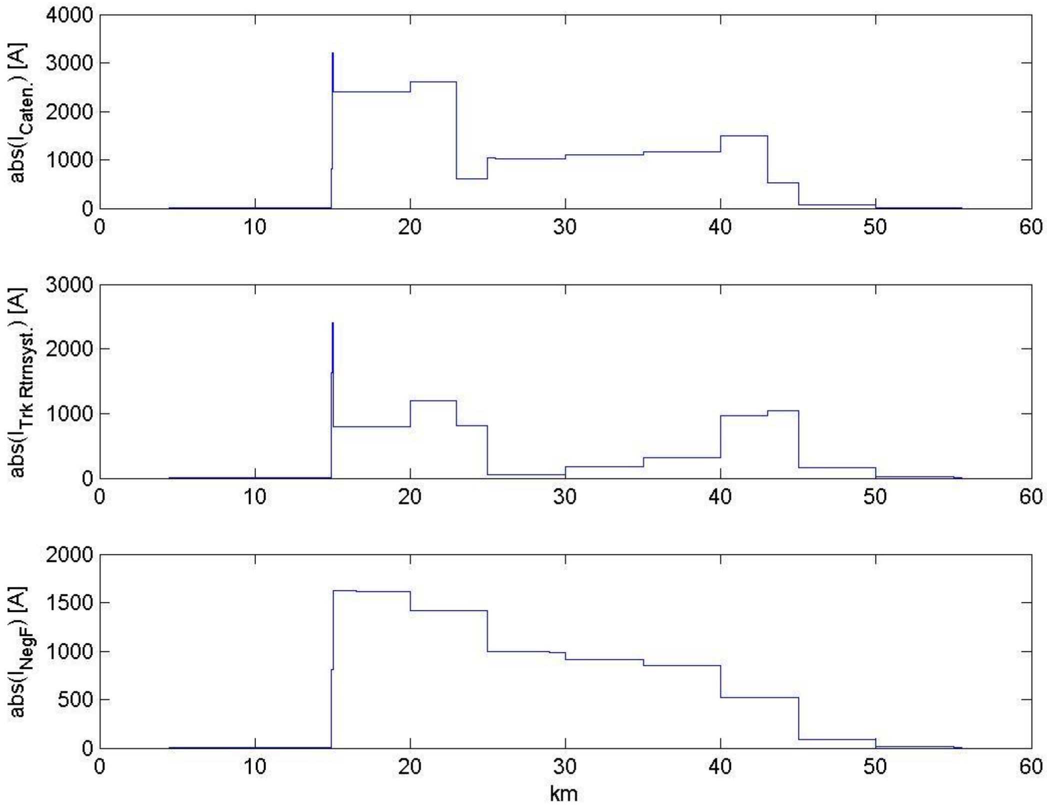
Figure A2.1: Overview concerning the position of the feeder station (km 15), two trains with 1000 A, PF 0.95 each at km 22.5 and two trains with 1000 A, PF 0.95 each at km 42.5



1.1.3 Due to the auto-transformer system the currents in the overhead contact system (OCS) differs generally from the traction load current. Thereby the distribution of currents on the systems catenary, rails-earth-wire-earth (i. e.

track return system) and autotransformer feeder depends amongst others on the auto transformer parameters, the position of the traction loads as well as the arrangement of the OCS conductors. Figure A2.2 presents the system currents along the modelled feeding section. In the simulation model the auto-transformer stations are placed at intervals of 5km. In order to simplify the power system model a 1 x 25 kV 50Hz feeder station is used with the associated autotransformers positioned 50 m downstream of the feeder station. The spikes shown in Figure A2.2 at km 15 are caused due to the selected feeder station model.

Figure A2.2: RMS-currents along the modelled feeding section in the catenaries, track-return-system and autotransformer feeders.



1.1.4 Concerning the positions of the conductors, Figure A2.3 shows the cross-sectional arrangement, which is implemented in this initial simulation. This is similar to, but not the same as, that proposed for HS2. Table A2.1 contains the conductor details. Please note that the conductor positions are for this initial simulation only. In a future project stage those details will be refined.

Figure A2.3: Cross sectional conductor arrangement

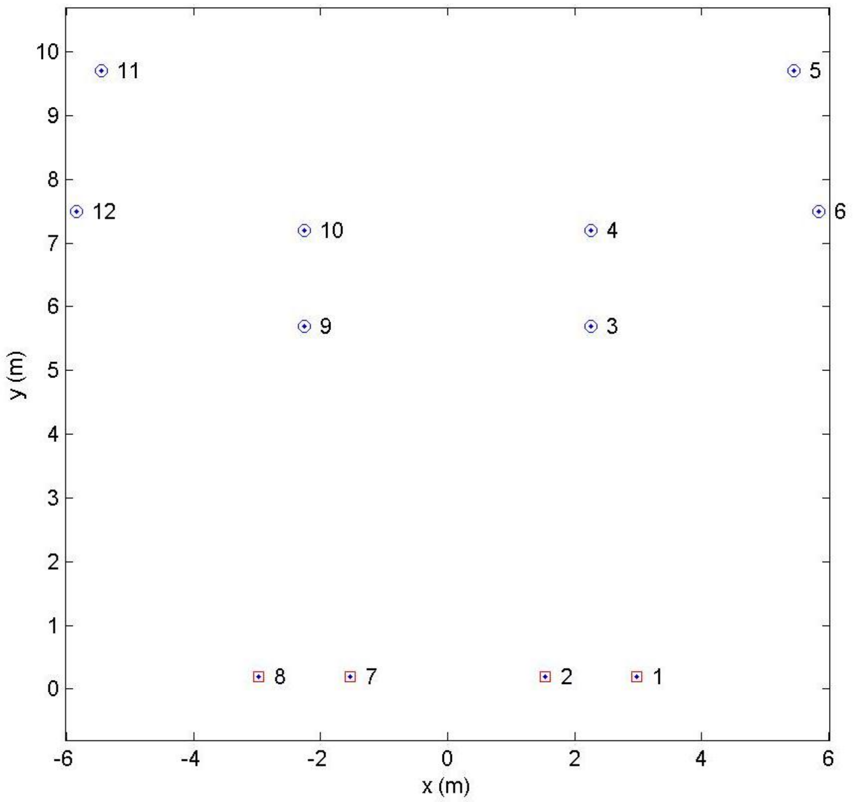


Table A2.1: Conductor details for the arrangement given in Figure A2.3

Conductor No.	Conductor	Material	x [m]	y [m]
1	Running rail	UIC60, 15 % wear	2.97	0.20
2	Running rail	UIC60, 15 % wear	1.53	0.20
3	Contact wire	Cu 120 mm², 15 % wear	2.25	5.70
4	Catenary wire	Cu 150 mm²	2.25	7.20
5	Negative feeder wire	Al 300 mm²	5.45	9.70
6	Aerial earth wire	Al 240 mm²	5.85	7.50
7	Running rail	UIC60, 15 % wear	-1.53	0.20
8	Running rail	UIC60, 15 % wear	-2.97	0.20
9	Contact wire	Cu 120 mm², 15 % wear	-2.25	5.70
10	Catenary wire	Cu 150 mm²	-2.25	7.20
11	Negative feeder wire	Al 300 mm²	-5.45	9.70
12	Aerial earth wire	Al 240 mm²	-5.85	7.50

1.1.5 Keeping in mind that the traction loads are placed at km 22.5 and km 42.5, the magnetic flux density has been calculated for positions km 17.5 (Figure A2.4), km 21.5 (Figure A2.5), km 24 (Figure A2.6), km 27.5 (Figure A2.7), km 32.5 (Figure A2.8), km 41.5 (Figure A2.9) and km 44 (Figure A2.10). From the contour plots it can be seen, that exposure to magnetic fields near to the railway line keeps changing from auto-transformer section to auto-transformer section. In auto-transformer sections with a traction load, the flux density levels near the catenary conductors and running rails are high compared to auto-transformer sections without trains (c. f. Figure A2.5, Figure A2.9). Figure A2.5 and Figure A2.9 indicate that at peak load conditions equipment installed near the running rails need to have high immunity levels for 50 Hz magnetic fields. A comparison with the limits given in Table 4.2.2.1 for train detection / control and signalling equipment implies that the calculated field levels do not exceed the critical value of 126µT or 100A/m. Regarding the electric, electronic and information technology equipment for industrial environment a limit of 30A/m or 37.7µT applies (Table 4.2.2.1). Based on the results given in Figures A2.4, A2.5 and A2.9 it is concluded that such equipment needs to be placed 8m away from the centre of the HS2 line to make sure that the permitted limits are not exceeded under worst case conditions. Audio-visual apparatus for industrial applications withstand fields of 10A/m or 12.6µT. Those field levels seems to be maintained, if audio-visual-equipment for industrial environment is placed at distance of 10.5 m or more from the centre of the HS2 line (Figures A2.4, A2.5 and A2.9).

1.1.6 Concerning the limit of 200µT for the general public, from the field plots Figures A2.4 to A2.10 it is expected that non-permissible values do not occur for areas where members of the public are staying.

1.1.7 With respect to the current flow direction for the values given in Tables A2.2 to A2.8 the reference direction is from the feeder station to the traction loads or in direction of increasing km for all conductor currents.

Table A2.2: Conductor and system currents associated with Figure A2.4

Line-km: 17.5, sub section no.: 29						
Cond. No.	x [m]	y [m]	Real(I) [A]	Imag(I) [A]	Abs(I) [A]	Angle(I) [Degr]
1	2.97	0.2	-87.3	62.9	55.9	168.7
2	1.53	0.2	-90.7	64.7	58.3	167.2
3	2.25	5.7	481.2	-308.3	406.4	-31.7
4	2.25	7.2	509.6	-376.2	150.2	-11.6
5	5.45	9.7	-641.8	492.8	447.8	144.8
6	5.85	7.5	-105.3	37.5	27.2	-107.3
7	-1.53	0.2	-90.7	64.7	58.3	167.2
8	-2.97	0.2	-87.3	62.9	56.0	168.7
9	-2.25	5.7	481.2	-308.3	406.4	-31.7
10	-2.25	7.2	509.6	-376.2	150.2	-11.7
11	-5.45	9.7	-641.8	492.8	447.9	144.8
12	-5.85	7.5	-105.4	37.5	27.2	-107.4
Earth			-131.1	53.3	141.5	157.9
Catenaries			1981.5	-1369.0	2408.4	-34.6
Track return system			-697.9	383.4	796.3	151.2
Neg feeder			-1283.5	985.5	1618.3	142.5
Traction current			3265.0	-2354.5	4025.4	-35.8

Figure A2.4: Contour plots for the magnetic field density, conductor currents in Table A2.2

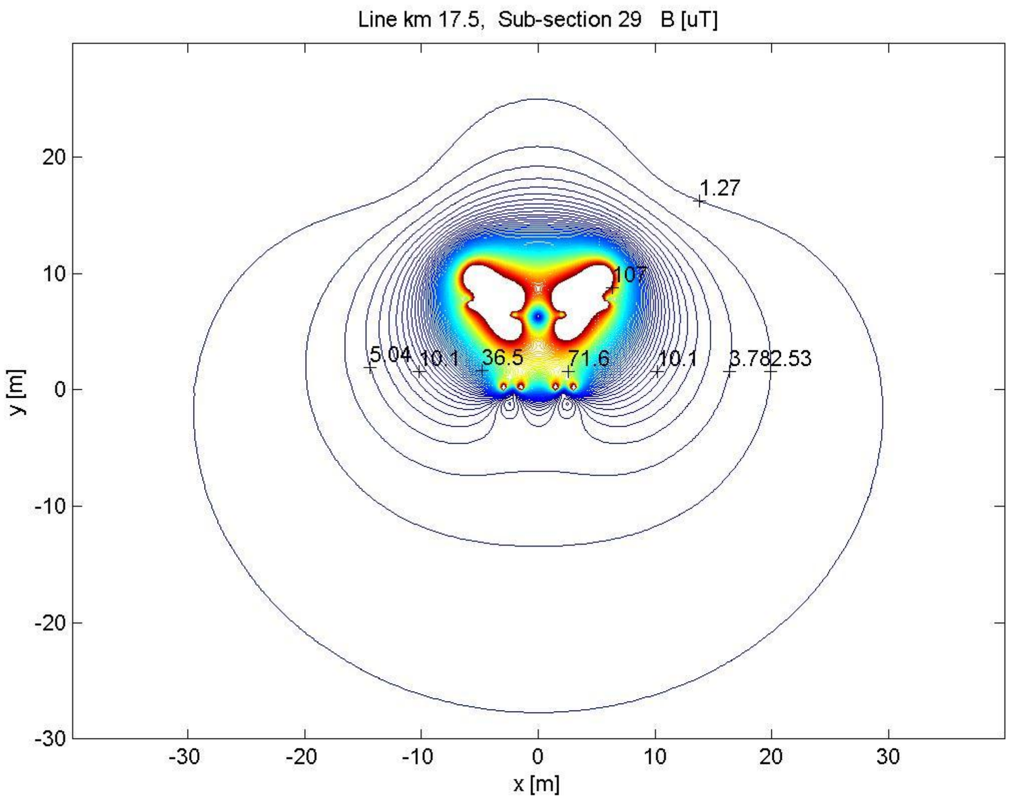


Table A2.3: Conductor and system currents associated with Figure A2.5

Line-km: 21.5, sub-section no.: 37						
Cond. No.	x [m]	y [m]	Real(I) [A]	Imag(I) [A]	Abs(I) [A]	Angle(I) [Degr]
1	2.97	0.2	-118.6	102.5	55.9	168.7
2	1.53	0.2	-120.6	102.3	58.3	167.2
3	2.25	5.7	525.0	-337.9	406.4	-31.7
4	2.25	7.2	545.8	-408.3	150.2	-11.6
5	5.45	9.7	-560.4	430.8	447.8	144.8
6	5.85	7.5	-207.1	104.4	27.2	-107.3
7	-1.53	0.2	-120.6	102.3	58.3	167.2
8	-2.97	0.2	-118.6	102.5	56.0	168.7
9	-2.25	5.7	525.0	-337.9	406.4	-31.7
10	-2.25	7.2	545.8	-408.3	150.2	-11.7
11	-5.45	9.7	-560.4	430.8	447.9	144.8
12	-5.85	7.5	-207.1	104.4	27.2	-107.4
Earth			-128.1	12.5	128.7	174.4
Catenaries			2141.5	-1492.4	2610.2	-34.9
Track return system			-1020.7	630.8	1199.9	148.3
Neg feeder			-1120.9	861.6	1413.8	142.5
Traction current			3262.4	-2354.0	4023.0	-35.8

Figure A2.5: Contour plots for the magnetic field density, conductor currents in Table A2.3

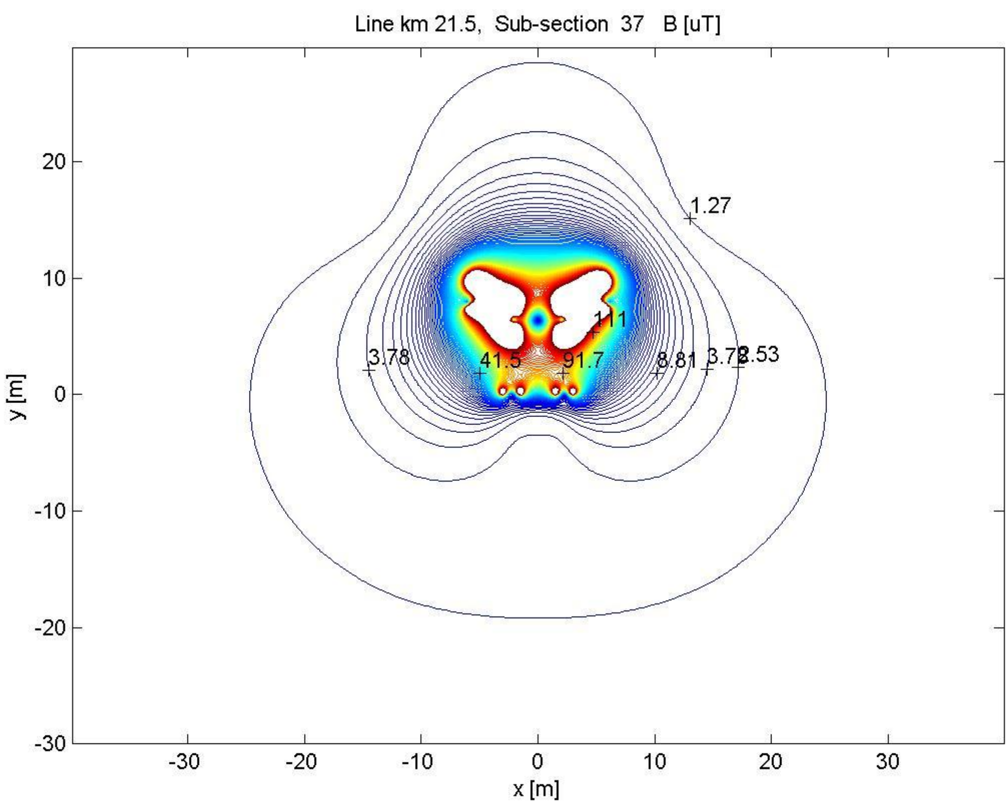


Table A2.4: Conductor and system currents associated with Figure A2.6

Line-km: 24, sub-section no.: 42						
Cond. No.	x [m]	y [m]	Real(I) [A]	Imag(I) [A]	Abs(I) [A]	Angle(I) [Degr]
1	2.97	0.2	39.9	-57.5	55.9	168.7
2	1.53	0.2	35.4	-52.1	58.3	167.2
3	2.25	5.7	95.1	-92.4	406.4	-31.7
4	2.25	7.2	127.1	-117.2	150.2	-11.6
5	5.45	9.7	-560.1	430.7	447.8	144.8
6	5.85	7.5	220.5	-128.8	27.2	-107.3
7	-1.53	0.2	35.4	-52.1	58.3	167.2
8	-2.97	0.2	39.9	-57.5	56.0	168.7
9	-2.25	5.7	95.1	-92.4	406.4	-31.7
10	-2.25	7.2	127.1	-117.2	150.2	-11.7
11	-5.45	9.7	-560.1	430.7	447.9	144.8
12	-5.85	7.5	220.5	-128.8	27.2	-107.4
Earth			84.3	34.5	91.1	202.3
Catenaries			444.5	-419.2	611.0	-43.3
Track return system			675.8	-442.2	807.6	146.8
Neg feeder			-1120.2	861.5	1413.2	142.4
Traction current			1564.7	-1280.7	2022.0	-39.3

Figure A2.6: Contour plots for the magnetic field density, conductor currents in Table A2.4

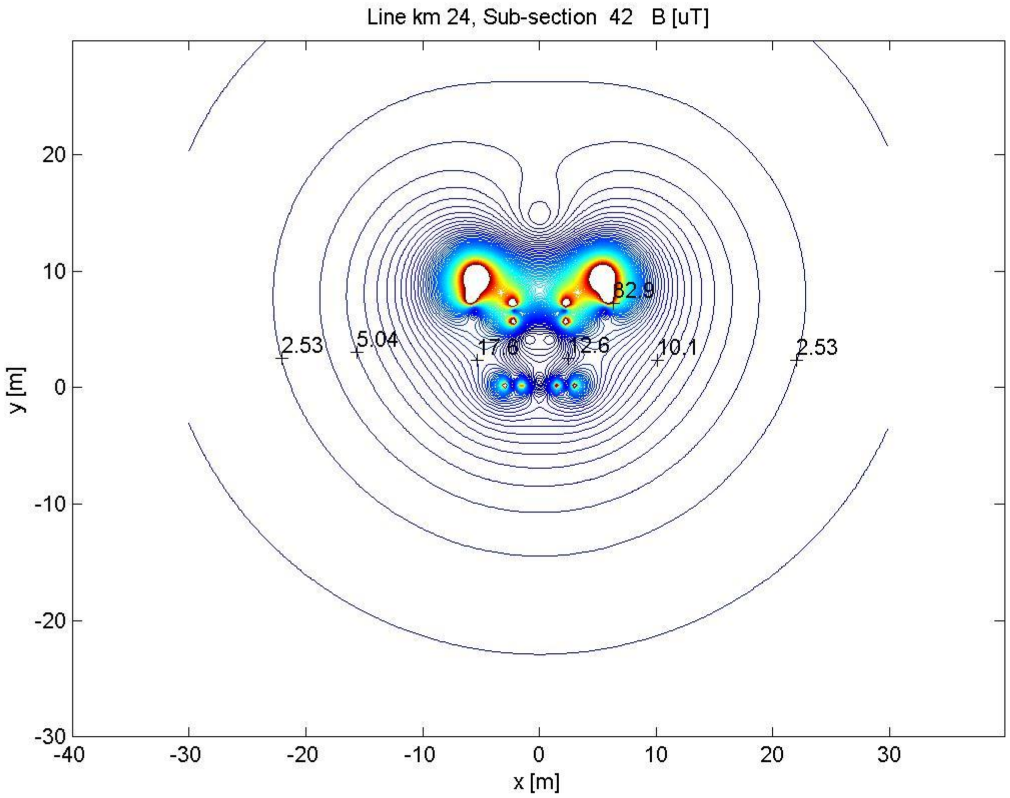


Table A2.5: Conductor and system currents associated with Figure A2.7

Line-km: 27.5, sub-section no.: 49						
Cond. No.	x [m]	y [m]	Real(I) [A]	Imag(I) [A]	Abs(I) [A]	Angle(I) [Degr]
1	2.97	0.2	-20.9	16.7	55.9	168.7
2	1.53	0.2	-23.0	18.4	58.3	167.2
3	2.25	5.7	188.6	-150.3	406.4	-31.7
4	2.25	7.2	205.7	-181.1	150.2	-11.6
5	5.45	9.7	-387.0	308.7	447.8	144.8
6	5.85	7.5	19.7	-4.6	27.2	-107.3
7	-1.53	0.2	-23.0	18.4	58.3	167.2
8	-2.97	0.2	-20.9	16.7	56.0	168.7
9	-2.25	5.7	188.6	-150.3	406.4	-31.7
10	-2.25	7.2	205.7	-181.1	150.2	-11.7
11	-5.45	9.7	-387.0	308.7	447.9	144.8
12	-5.85	7.5	19.7	-4.6	27.2	-107.4
Earth			33.6	-15.4	37.0	155.3
Catenaries			788.6	-662.8	1030.2	-40.0
Track return system			-14.7	45.5	47.8	107.9
Neg feeder			-773.9	617.3	990.0	141.4
Traction current			1562.5	-1280.2	2020.0	-39.3

Figure A2.7: Contour plots for the magnetic field density, conductor currents in Table A2.5

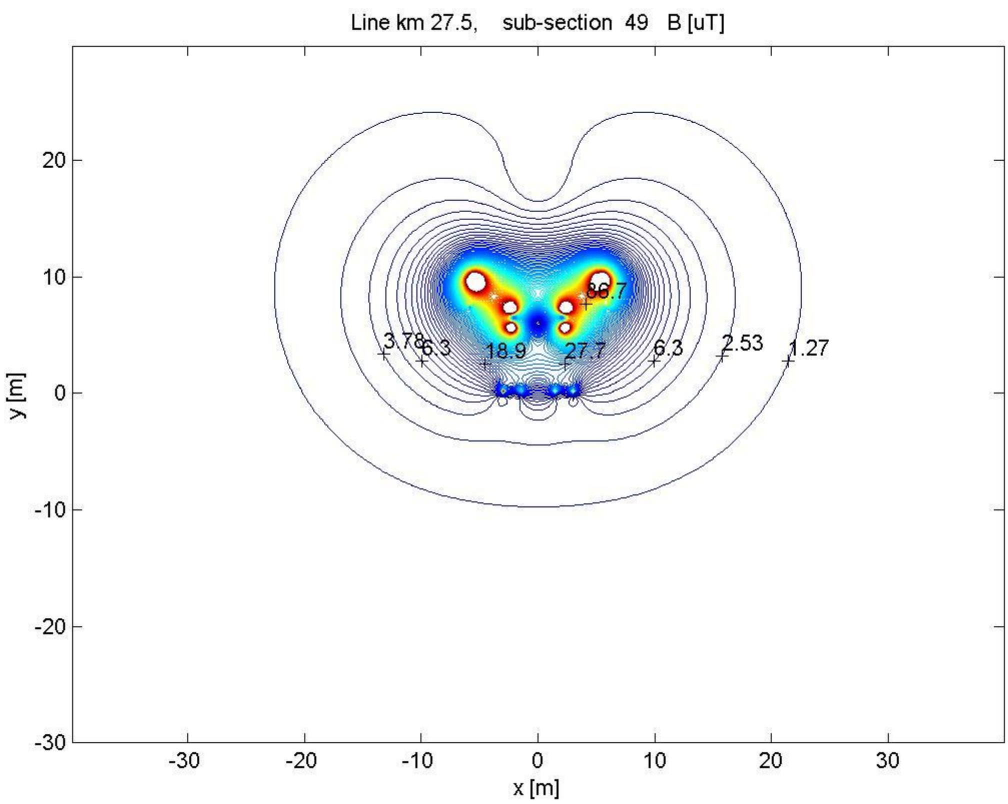


Table A2.6: Conductor and system currents associated with Figure A2.8

Line-km: 32.5, sub-section no.: 59						
Cond. No.	x [m]	y [m]	Real(I) [A]	Imag(I) [A]	Abs(I) [A]	Angle(I) [Degr]
1	2.97	0.2	-29.1	22.7	55.9	168.7
2	1.53	0.2	-31.0	24.2	58.3	167.2
3	2.25	5.7	205.9	-157.5	406.4	-31.7
4	2.25	7.2	221.0	-190.0	150.2	-11.6
5	5.45	9.7	-352.9	292.2	447.8	144.8
6	5.85	7.5	-8.4	4.2	27.2	-107.3
7	-1.53	0.2	-31.0	24.2	58.3	167.2
8	-2.97	0.2	-29.1	22.7	56.0	168.7
9	-2.25	5.7	205.9	-157.5	406.4	-31.7
10	-2.25	7.2	221.0	-190.0	150.2	-11.7
11	-5.45	9.7	-352.9	292.2	447.9	144.8
12	-5.85	7.5	-8.4	4.2	27.2	-107.4
Earth			-11.0	8.4	13.8	142.8
Catenaries			853.8	-695.0	1100.9	-39.1
Track return system			-148.0	110.6	184.8	143.2
Neg feeder			-705.8	584.3	916.3	140.4
Traction current			1559.5	-1279.3	2017.1	-39.4

Figure A2.8: Contour plots for the magnetic field density, conductor currents in Table A2.6

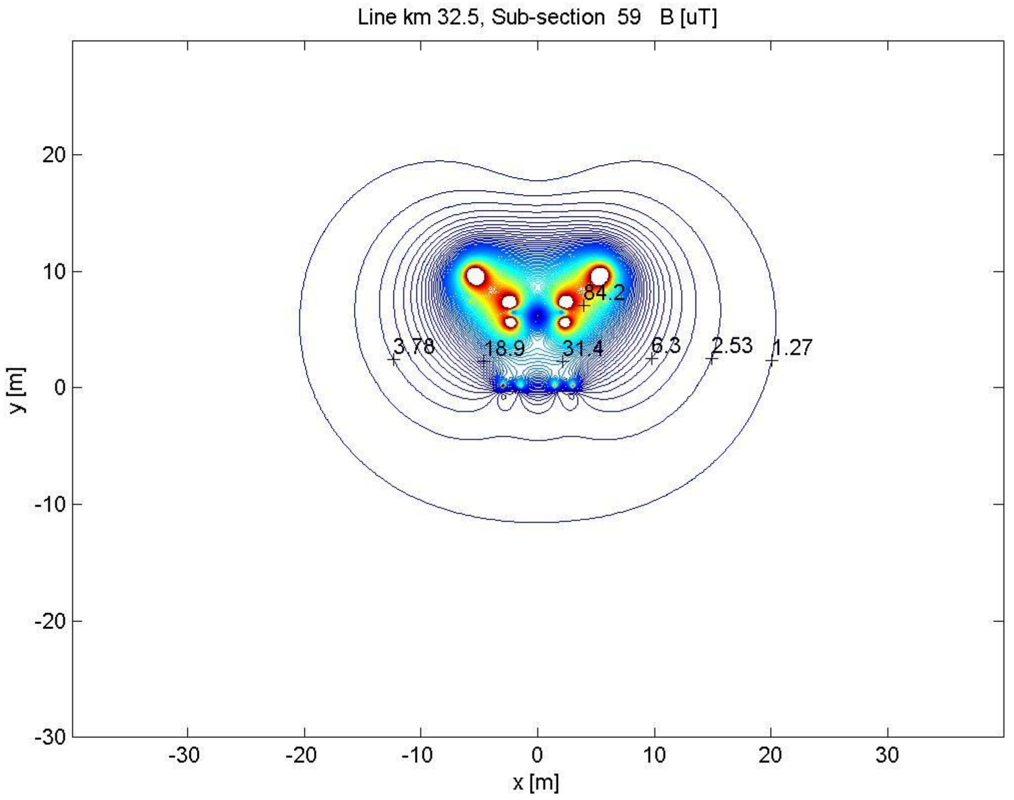


Table A2.7: Conductor and system currents associated with Figure A2.9

Line-km: 41.5, sub-section no.: 77						
Cond. No.	x [m]	y [m]	Real(I) [A]	Imag(I) [A]	Abs(I) [A]	Angle(I) [Degr]
1	2.97	0.2	-75.7	89.3	55.9	168.7
2	1.53	0.2	-76.1	87.6	58.3	167.2
3	2.25	5.7	287.4	-216.1	406.4	-31.7
4	2.25	7.2	289.0	-253.5	150.2	-11.6
5	5.45	9.7	-200.7	169.3	447.8	144.8
6	5.85	7.5	-174.7	123.3	27.2	-107.3
7	-1.53	0.2	-76.1	87.6	58.3	167.2
8	-2.97	0.2	-75.7	89.3	56.0	168.7
9	-2.25	5.7	287.4	-216.1	406.4	-31.7
10	-2.25	7.2	289.0	-253.5	150.2	-11.7
11	-5.45	9.7	-200.7	169.3	447.9	144.8
12	-5.85	7.5	-174.7	123.3	27.2	-107.4
Earth			-98.5	0.2	98.5	179.9
Catenaries			1152.9	-939.1	1487.0	-39.2
Track return system			-751.5	600.6	962.0	141.4
Neg feeder			-401.4	338.5	525.1	139.9
Traction current			1554.3	-1277.6	2012.0	-39.4

Figure A2.9: Contour plots for the magnetic field density, conductor currents in Table A2.7

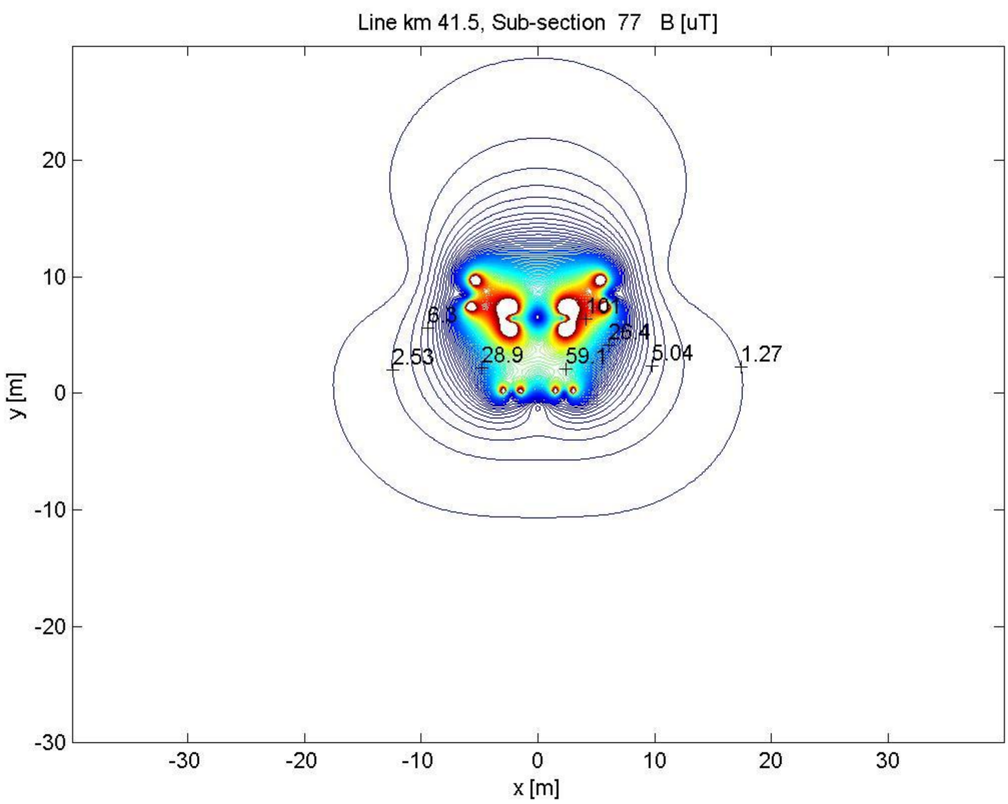
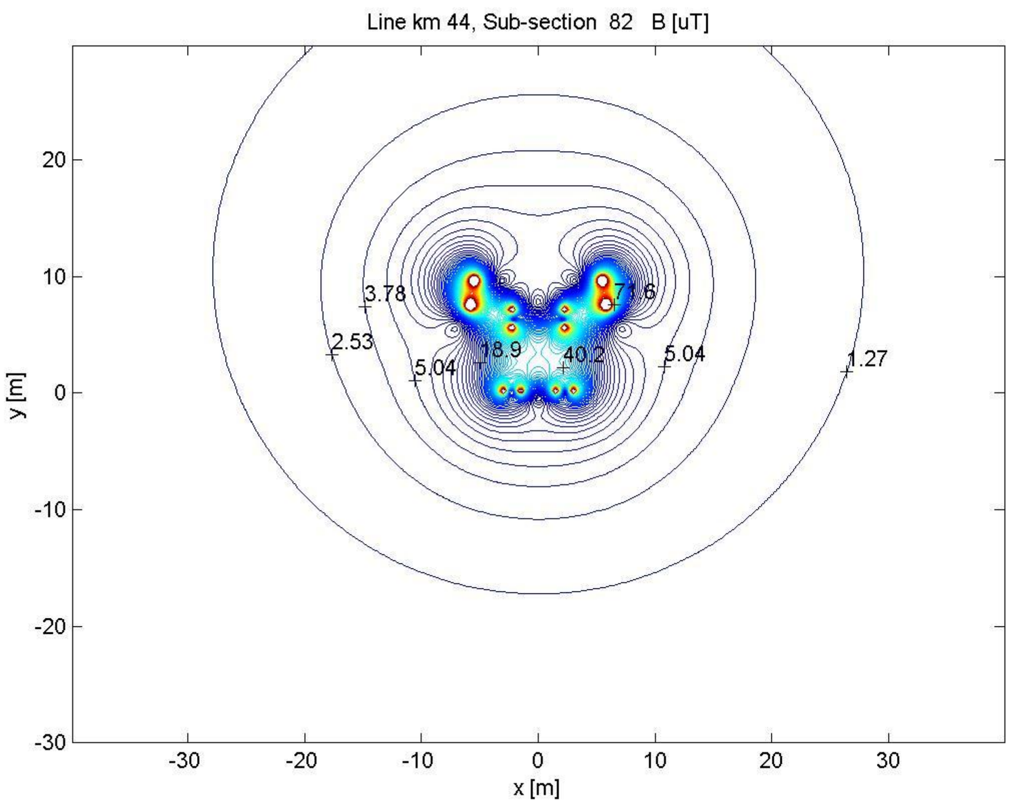


Table A2.8: Conductor and system currents associated with Figure A2.10

Line-km: 44, sub-system no.: 82						
Cond. No.	x [m]	y [m]	Real(I) [A]	Imag(I) [A]	Abs(I) [A]	Angle(I) [Degr]
1	2.97	0.2	62.4	-90.6	55.9	168.7
2	1.53	0.2	60.3	-86.4	58.3	167.2
3	2.25	5.7	-107.9	80.9	406.4	-31.7
4	2.25	7.2	-89.5	87.1	150.2	-11.6
5	5.45	9.7	-200.4	169.2	447.8	144.8
6	5.85	7.5	222.7	-163.6	27.2	-107.3
7	-1.53	0.2	60.3	-86.4	58.3	167.2
8	-2.97	0.2	62.4	-90.6	56.0	168.7
9	-2.25	5.7	-107.9	80.9	406.4	-31.7
10	-2.25	7.2	-89.5	87.1	150.2	-11.7
11	-5.45	9.7	-200.4	169.2	447.9	144.8
12	-5.85	7.5	222.7	-163.6	27.2	-107.4
Earth			104.7	6.8	104.9	183.7
Catenaries			-394.7	336.0	518.3	-40.4
Track return system			795.6	-674.3	1042.9	139.7
Neg feeder			-400.9	338.3	524.6	139.8
Traction current			6.2	-2.3	6.6	-20.3

Figure A2.10: Contour plots for the magnetic field density, conductor currents in Table A2.8



2 Induced voltage

2.1.1 For the model described in Section 1, the per-length induced voltages have been calculated for km 17.5 (Figure A3.1), km 21.5 (Figure A3.2), km 24 (Figure A3.3), km 27.5 (Figure A3.4), km 32.5 (Figure A3.5), km 41.5 (Figure A3.6) and km 44 (Figure A3.7). As the currents in the catenaries, track return system and autotransformer feeder wires change for each AT section; the induced voltages vary along the railway line (c. f. Figure A3.1 to A3.7). Comparing Figures A3.2 and A3.6 with Figures A3.4 and Figure A3.5 it can be seen that generally the induced voltages are higher along auto-transformer sections with a traction load than at auto-transformer sections without a traction load. The reason for this phenomenon is that along auto-transformer section without trains the proportion of currents in the track return system, i. e. running rails including earth and earth wires, with respect to the total traction current is lower compared to auto-transformer sections with a train in between two neighbouring auto-transformer stations.

2.1.2 The plots related to the train-in-section-effects (Figures A3.2 and A3.6) and where the autotransformer feeder currents do not primarily compensate the magnetic fields from the catenary currents (Figure A3.1) show local maxima at distances of 2m to 3m from the centre of adjacent tracks. In order to enhance immunisation on lineside cables the placement of cable troughs at locations where local maxima occur should be avoided.

2.1.3 Assuming a cable is placed with a separation of about 6m from an adjacent track centre (x = 8.5 m in Figures A3.1 to A3.7). Furthermore it is assumed that this cable has a permissible limit on the induced voltage of 150V. In Figure A3.1 the induced voltage per km is about 52V at x = 8.5m. This means the cable length shall be limited to 2.8km to ensure that the 150V limit is not exceeded.

2.1.4 The results present initial levels of induced voltages. More accurate results will be produced in future simulations based on refined computer models.

Figure A3.1: Per length induced voltage perpendicular to the railway line, the y-level (height) of the affected cable varies from y = - 0.4 m to y = 0.1 m, where the rails are placed at y = 0.2 m

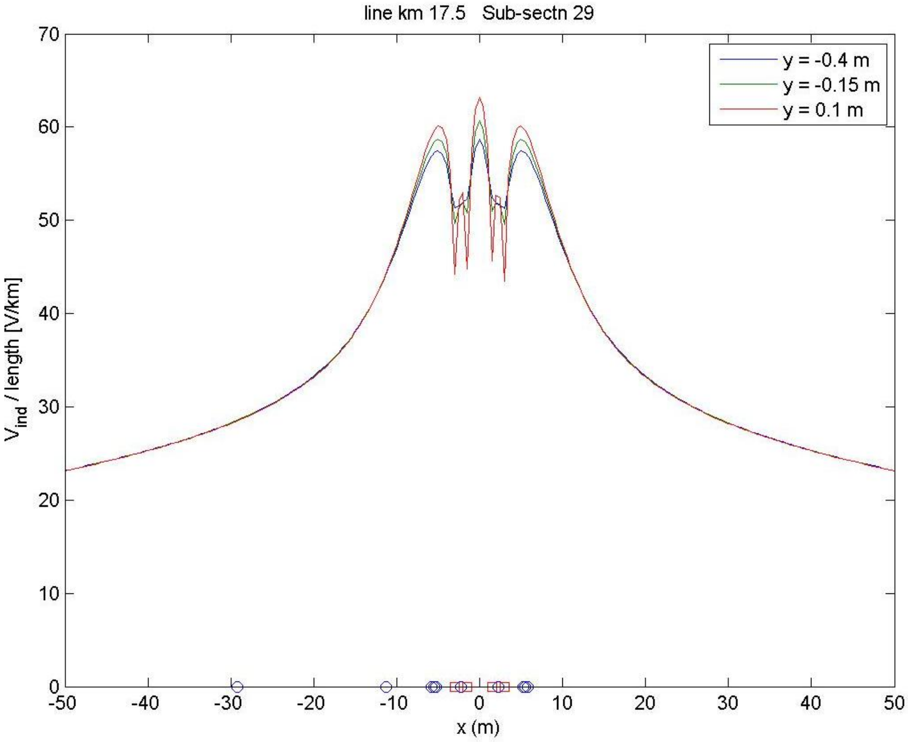


Figure A3.2: Per length induced voltage perpendicular to the railway line, the y-level (height) of the affected cable varies from y = - 0.4 m to y = 0.1 m, where the rails are placed at y = 0.2 m

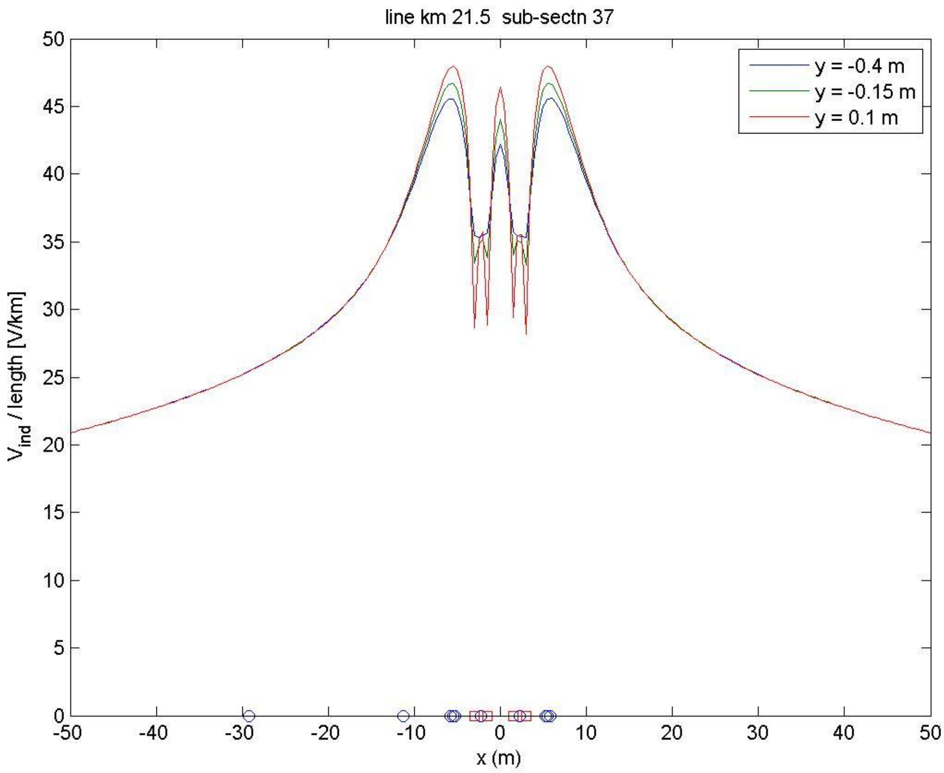


Figure A3.3: Per length induced voltage perpendicular to the railway line, the y-level (height) of the affected cable varies from y = - 0.4 m to y = 0.1 m, where the rails are placed at y = 0.2 m

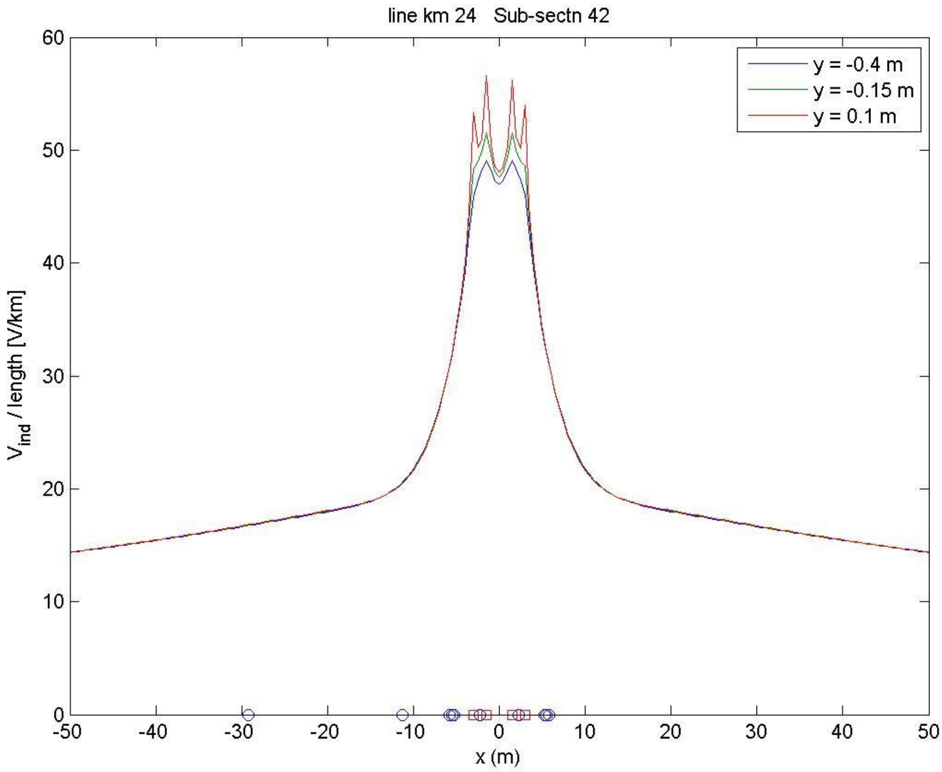


Figure A3.4: Per length induced voltage perpendicular to the railway line, the y-level (height) of the affected cable varies from y = - 0.4 m to y = 0.1 m, where the rails are placed at y = 0.2 m

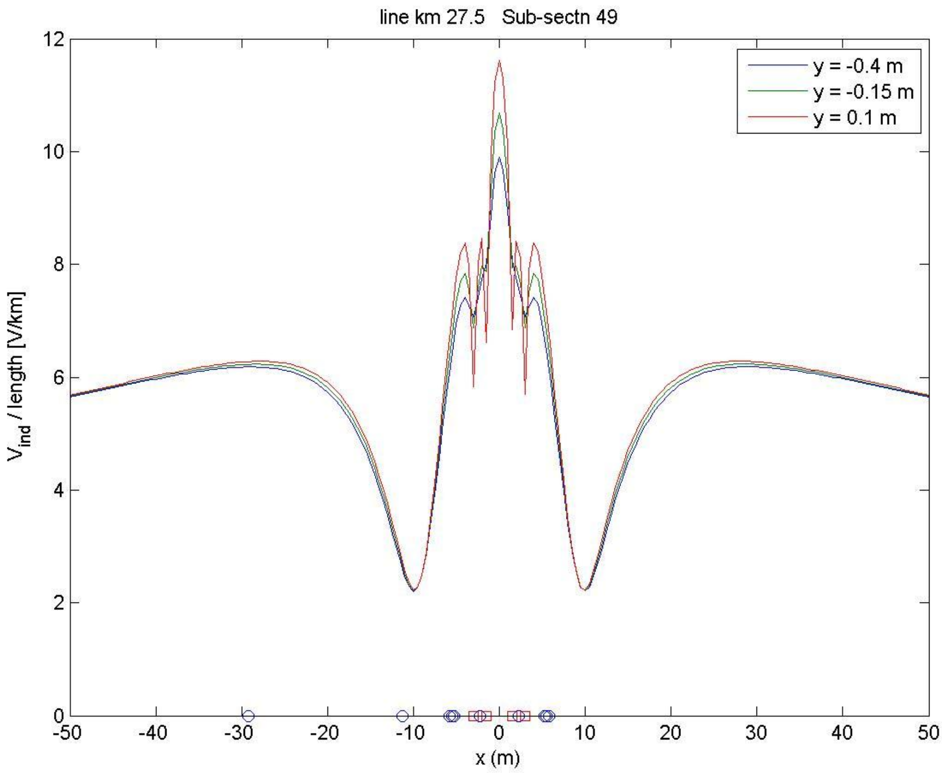


Figure A3.5: Per length induced voltage perpendicular to the railway line, the y-level (height) of the affected cable varies from y = - 0.4 m to y = 0.1 m, where the rails are placed at y = 0.2 m

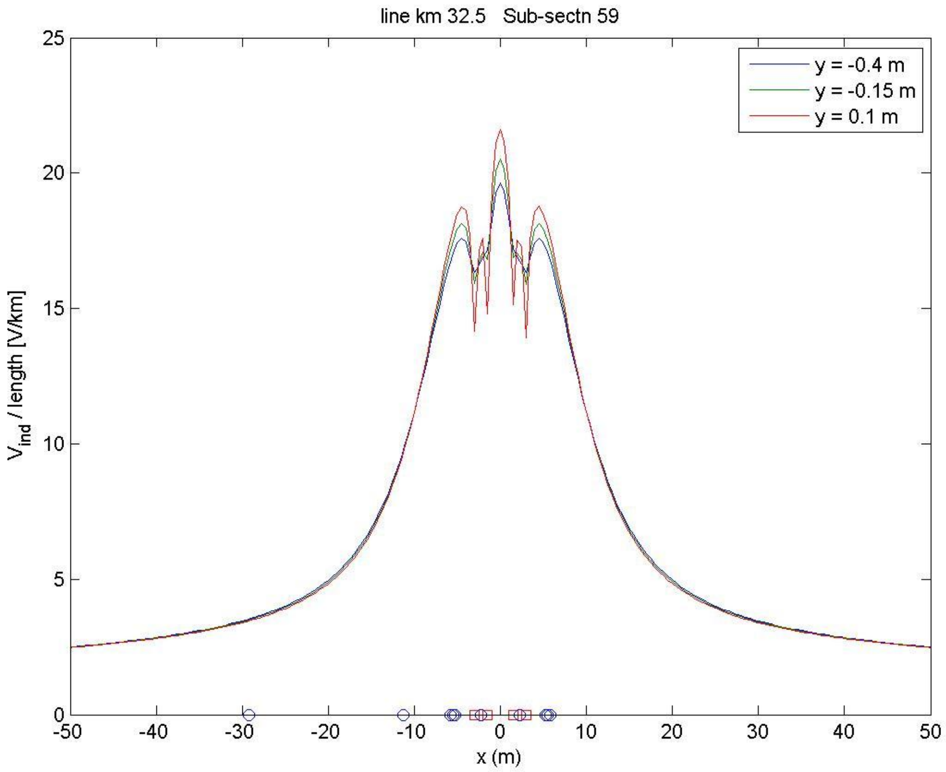


Figure A3.6: Per length induced voltage perpendicular to the railway line, the y-level (height) of the affected cable varies from y = - 0.4 m to y = 0.1 m, where the rails are placed at y = 0.2 m

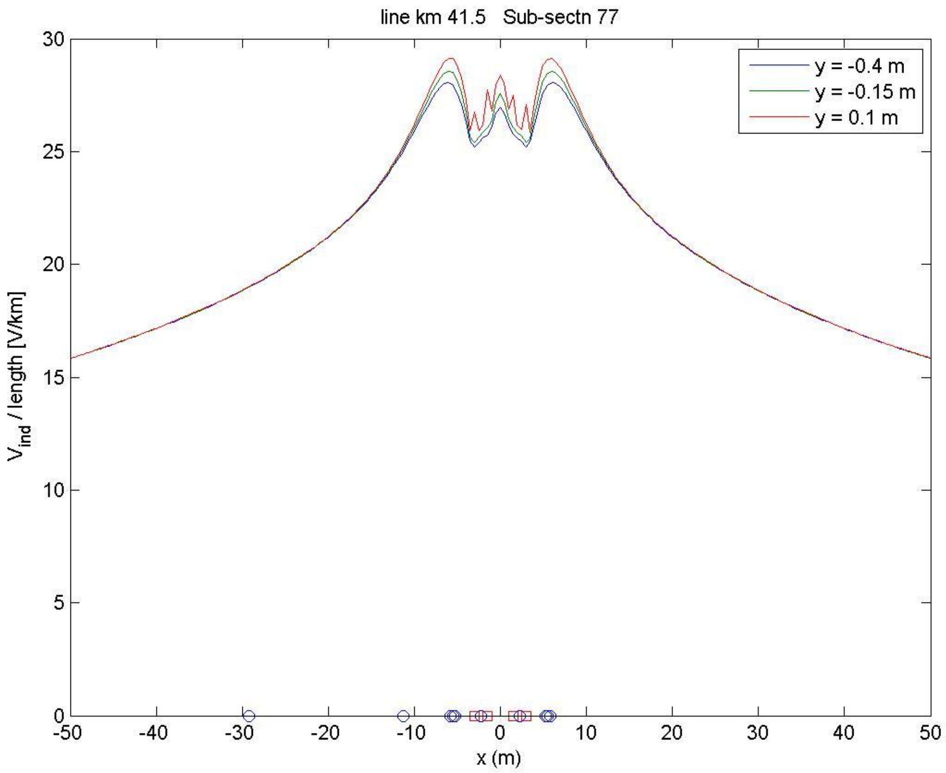


Figure A3.7: Per length induced voltage perpendicular to the railway line, the y-level (height) of the affected cable varies from y = - 0.4 m to y = 0.1 m, where the rails are placed at y = 0.2 m