The Voice of the Networks

Energy Networks Association

EMF Awareness in Distribution Networks

ENA EMF Strategy Committee
2013

Introduction

- Members of the public sometimes report instances of high magnetic fields.
- Sometimes these are nothing out of the ordinary. But sometimes they are produced by a network fault or an incipient network fault. Investigating the high fields helps us spot the network problem.
- This presentation explains these issues.

What this presentation will do

- Explain how high EMFs are produced
- Equip you to spot warning signs of a network problem

But NOT:

- Turn you into an EMF expert
- Train you to do an on-site investigation
    - This presentation will give you pointers to things to look out for when someone describes a problem to you, but if you were to investigate that problem properly, you would need a lot more information

EMFs

- Electric and Magnetic Fields
- They have established effects on humans at high enough levels
  - We protect against these by following exposure limits
- There is some evidence suggesting health effects at lower levels
  - Principally childhood leukaemia
  - We recognise the possibility but these are not established effects, the weight of evidence is against

Electric and magnetic fields

Electric fields

- Produced by voltage
- Measured in V/m or kV/m
- Screened by building materials

Magnetic fields

- Produced by current
- Measured in µT (“microteslas”)
- Pass through most building materials

- Most concern relates to magnetic not electric and this presentation concerns only magnetic fields (MFs)

EMFs: general messages

- Take all concerns seriously and treat all customers respectfully and sensitively
- Be completely open with all information
- Explain how our networks comply with exposure limits set by independent authorities

- This presentation does not cover the whole of EMFs!
- Further information:
  - www.emfs.info
  - Helpline 08457 023270 (run by National Grid on behalf of whole industry)

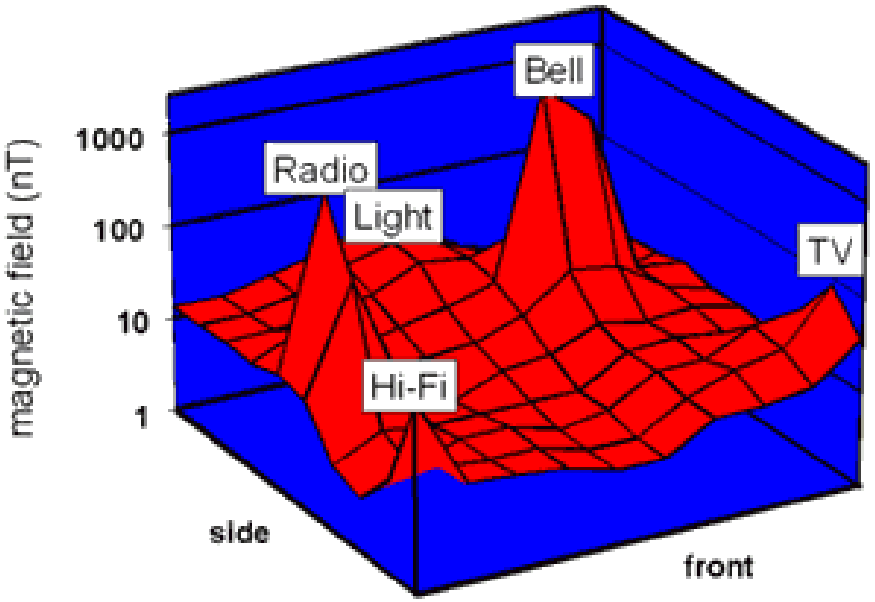
Measuring magnetic fields

- MFs measured in “microteslas” (µT)
  - Or sometimes nanoteslas, nT
  - 1000 nT=1 µT
  - For other units see http://www.emfs.info/What+are+EMFs/Terminology/Units.htm

Levels of magnetic field

- 100 μT: the “reference level” from the exposure limits for the public (the actual limit is 360 μT)
- 1 – 10 μT: typical level under a power line (depending on voltage and load)
- 0.4 μT: the level often identified from the scientific evidence as being where any risk of childhood leukaemia is doubled
- 0.01 – 0.2 μT: how we usually describe the range of fields in normal homes (average is 0.05 μT)

The magnetic field in a home



- Fields from each mains appliance
  - Typically only within 1 m
- Superimposed on “background field”
- It is the background field we are concerned with here, not elevated values near appliances

Where does the background field come from?

- Power line for the small fraction of homes close to them
  - A few metres at 11 kV up to say 100 m at 400 kV
- Substation for the even smaller fraction of homes close enough to them
  - Usually only within a few metres
- Otherwise, 400 V/230 V distribution circuits

How do distribution cables produce magnetic fields?

- In summary:
  - It's not as simple as just the loads they carry
  - It's the way they are earthed that results in unbalanced currents
- The next few slides explain this

The non-technical version

- The way we earth our low-voltage circuits often produces something called a “net current”
- It is this net current that is the source of MF in most homes
- Some net current is normal, but high net currents can be an indication of a problem:
  - A broken neutral conductor
  - Current diverting through a building

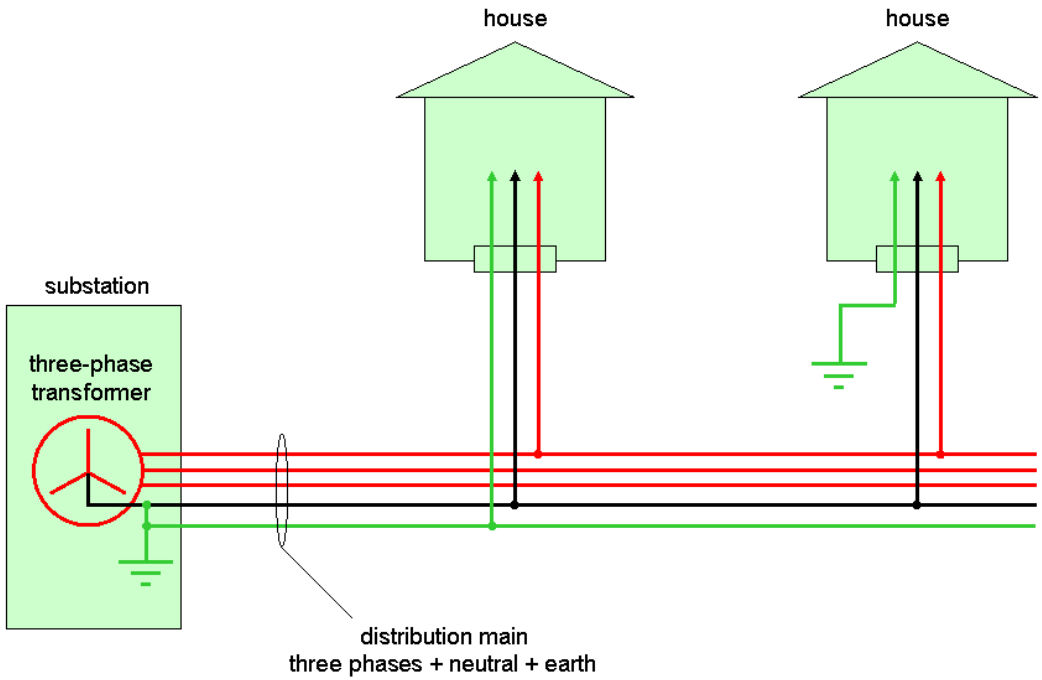
In a nutshell...

- High magnetic fields can sometimes be an indication of high net currents
- High net currents can sometimes be an indication of a problem we want to find out about.

To understand this in more detail, proceed to next slide

To skip the technical bits, go to slide 29

Simplest arrangement: Separate neutral and earth

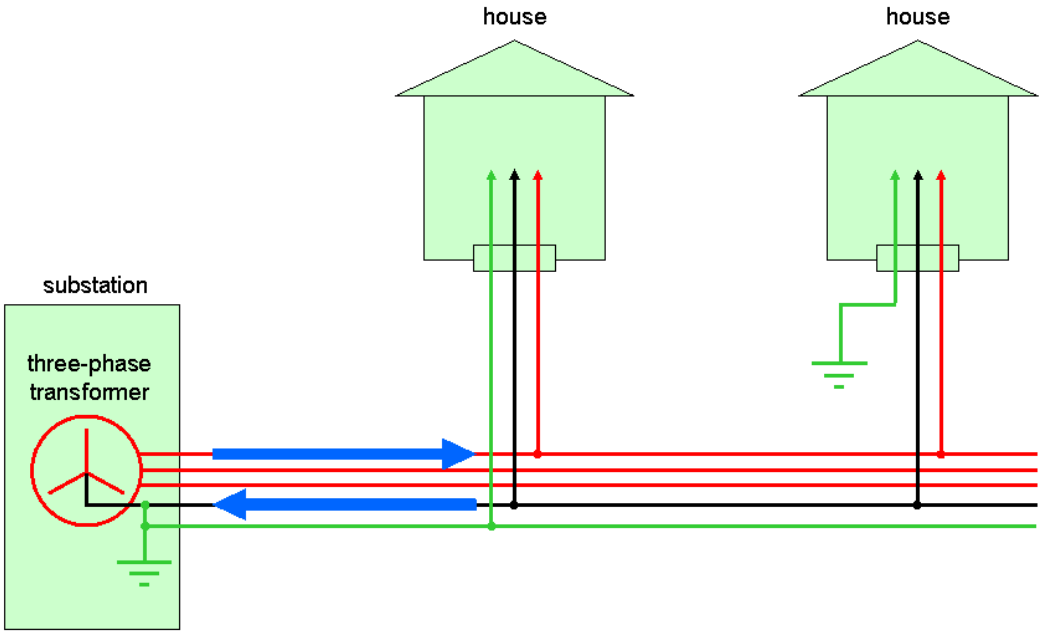


- Earthing provided by earth conductor or local earth at house
  - For our purposes it makes no difference whether the earth is provided through the earth conductor in the distribution circuit or through a local earth
  - Neutral is always earthed in substation but in this simple arrangement is not earthed anywhere else

Consequences of this arrangement
(earth and neutral separate outside substation)

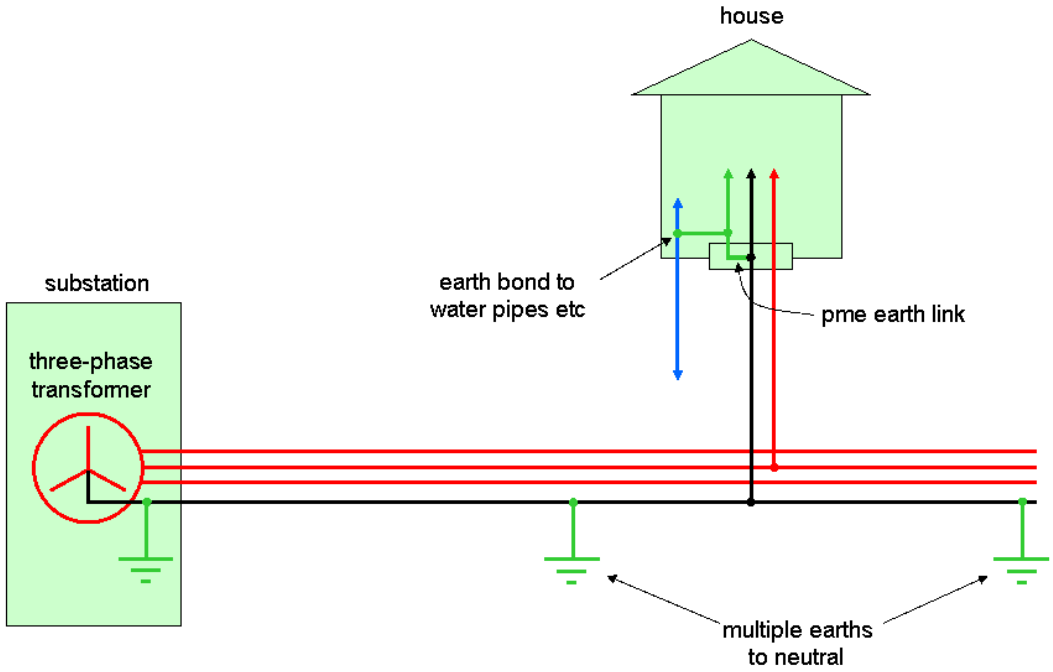
- Load currents flow out through phase conductor and back through neutral conductor
- Currents are equal and opposite
- Phase and neutral conductors are physically close together in the same cable
- Individual magnetic fields almost entirely cancel each other (at distances more than a few cm away)
- Very low external magnetic field

Consequences of this arrangement
(earth and neutral separate outside substation)



- Equal and opposite phase and neutral currents
- No net current
- Very low external field

Normal practice for circuits today
instead of the previous arrangement

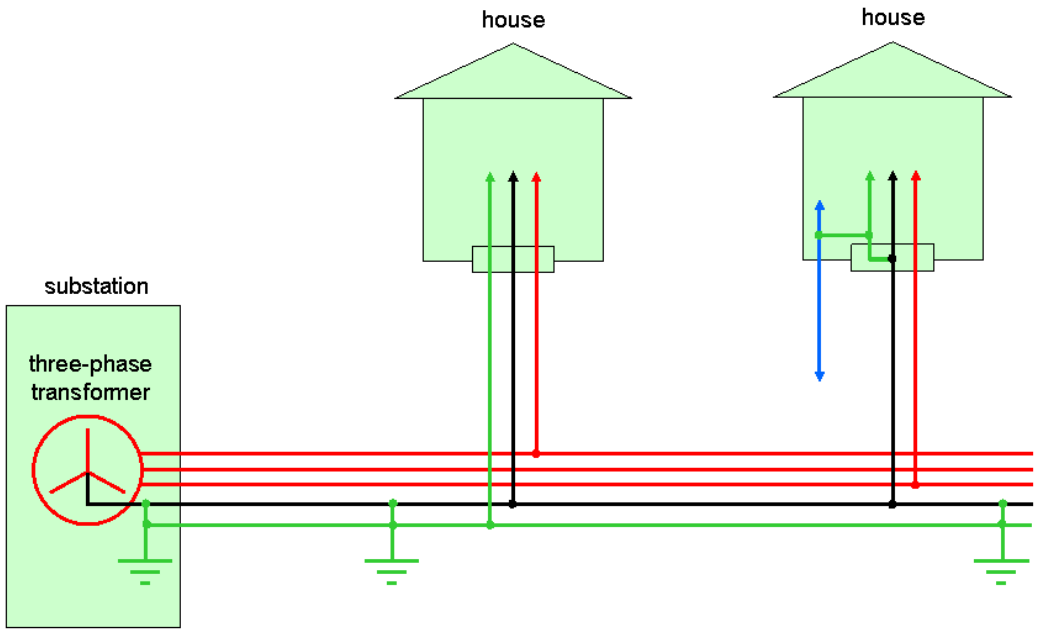


“Protective Multiple Earthing”(pme)

- Neutral also acts as earth – no separate earth conductor
- Neutral is earthed in multiple places

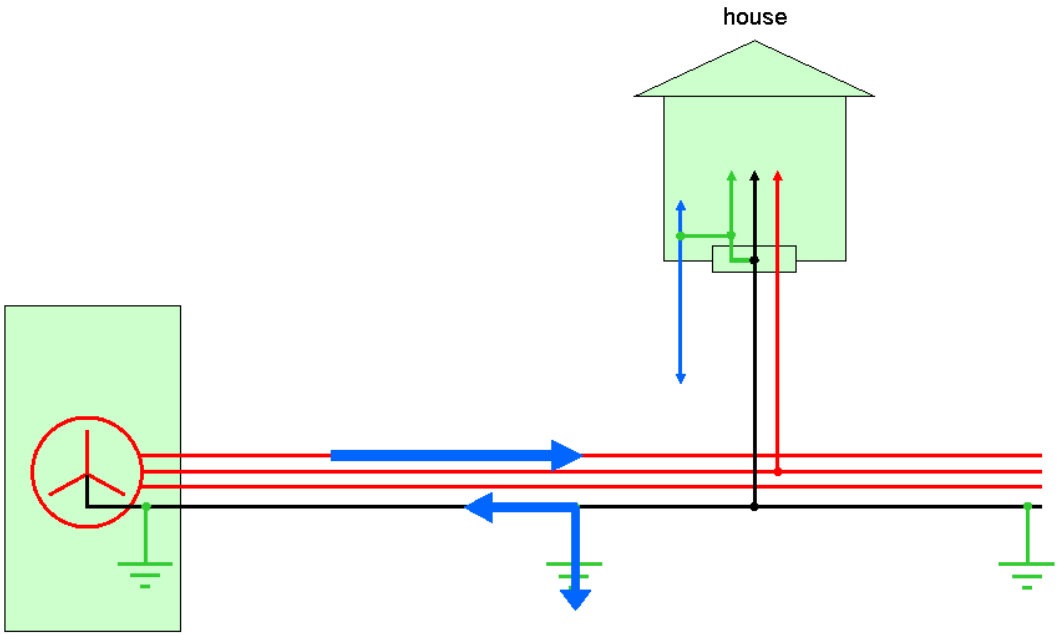
  (regulations specify where – ends of circuit, at intervals along circuit, and some individual homes)

Another common situation
An old system converted to pme



- Neutral is still multiply earthed
- For EMF purposes, this works in the same way as the previous diagram

Consequences of pme



- Some of the neutral current can divert out of the neutral into the ground
  - The amount which actually does so depends on the relative impedance of the different paths back to the substation

Consequences of pme

- Load current still has to flow out through phase conductor
- Neutral has alternative routes back via the earth connection
  - Can be in the earth itself or in water or gas pipes or building structures – anything that is conducting
- Currents are no longer balanced – the circuit has a "net current"
- Magnetic fields from phase and neutral conductors no longer effectively cancel

Net currents

- Are the main source of magnetic field in the great majority of UK homes
- Size of net current depends on
  - Size of load
  - How well the loads in the three phase conductors are balanced
  - Relative impedance for the neutral current to flow back to substation through earth connections compared to neutral conductor
- Average value in UK 3.6 A

Magnetic fields and net currents

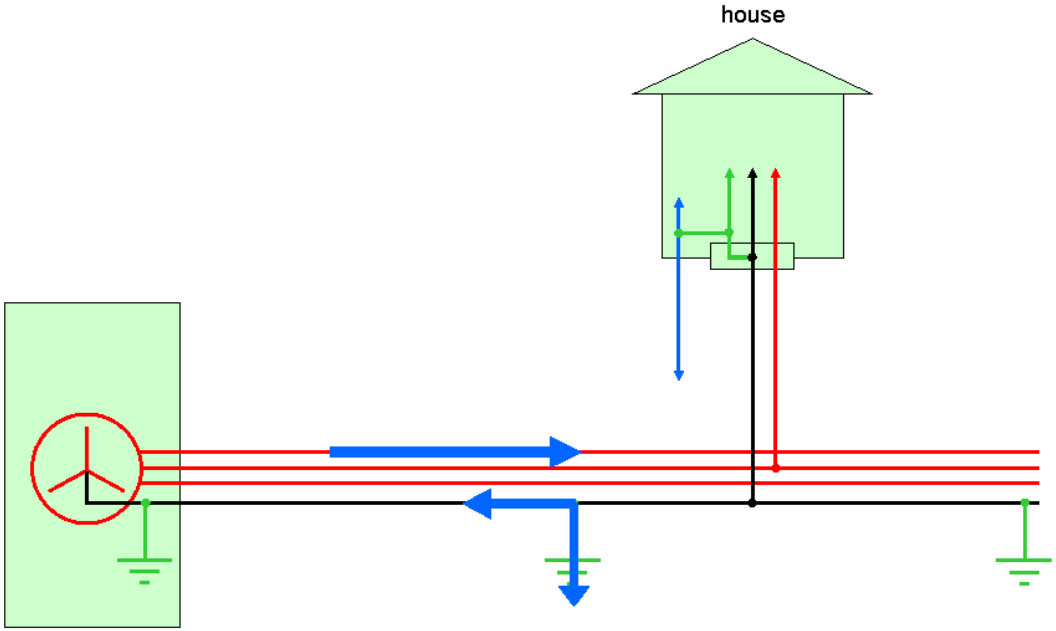
- Magnetic field in home depends on:
  - Size of net current
  - Distance of home from net current

    The main net current is usually on the distribution cable along the pavement but net currents can also flow into and through homes on the service cable, water pipes etc
- High magnetic fields could therefore:
  - just be that the home is unusually close to a net current
  - but could be an indication of unusually high net currents

What makes a high net current?

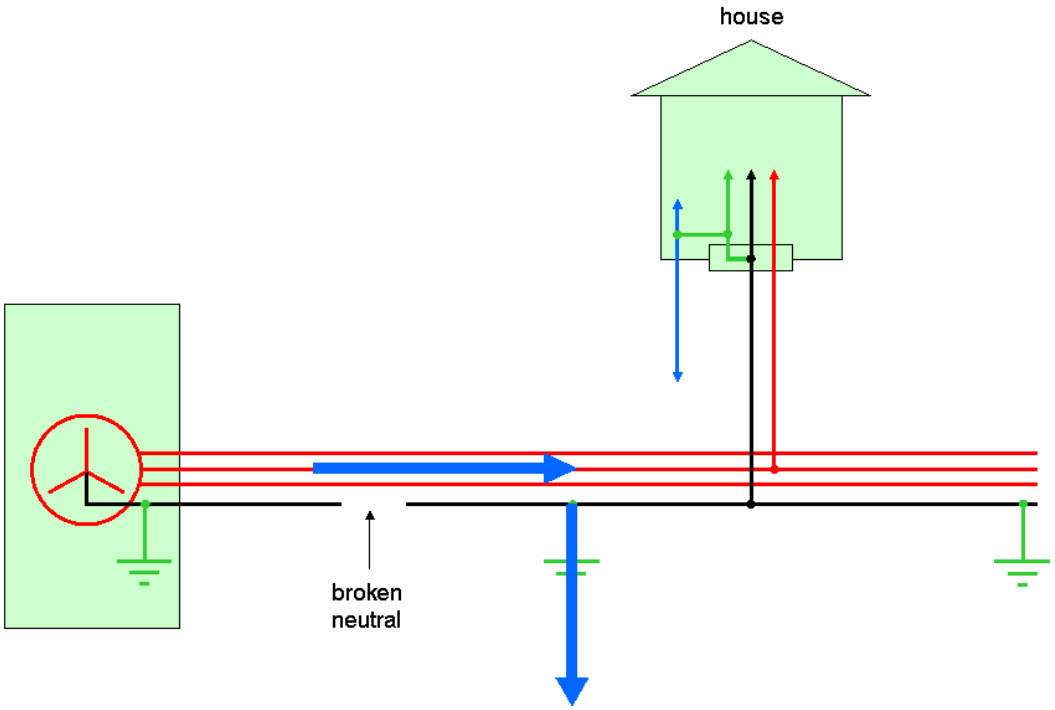
- High net currents can be:
  - Just a normal circuit where the value happens to be high
- Or the result of:
  - Unusually good earth connection through a building
  - Interrupted neutral
- These are potential problems and are explained in the next two slides

High net currents indicating a problem (1):
Currents flowing through a building



- The earth connection may be through the metal frame of a building
- If it is a good (low impedance) connection, the current may be quite high
- This is a safety hazard

High net currents indicating a problem (2): Interrupted neutrals

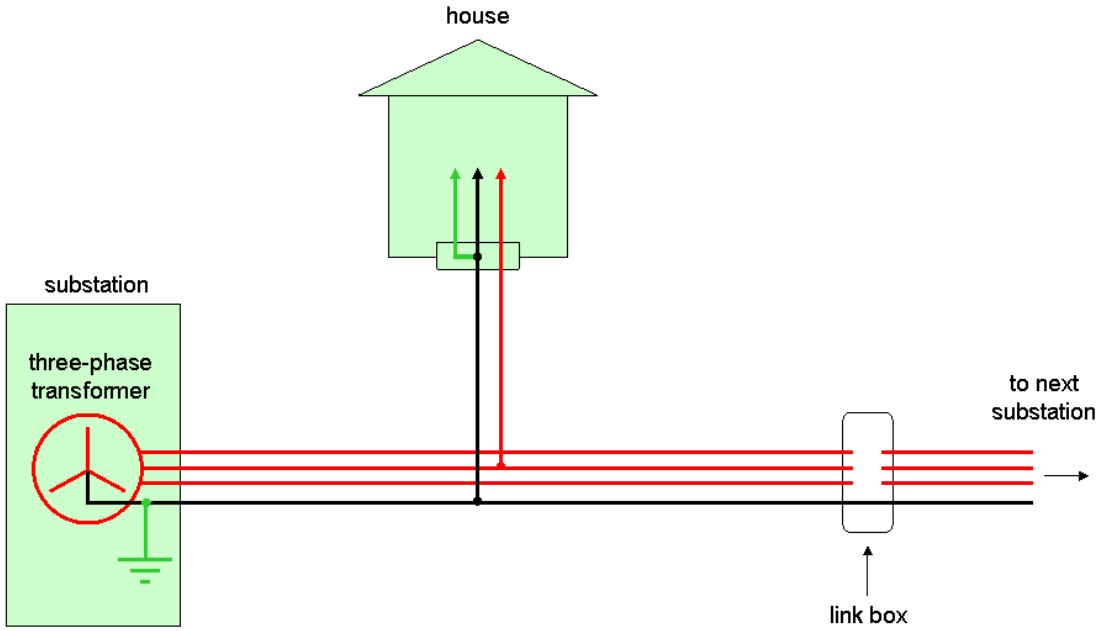


- A broken neutral conductor forces 100% of the neutral current to divert

High net currents indicating a problem (2): Interrupted **neutrals**

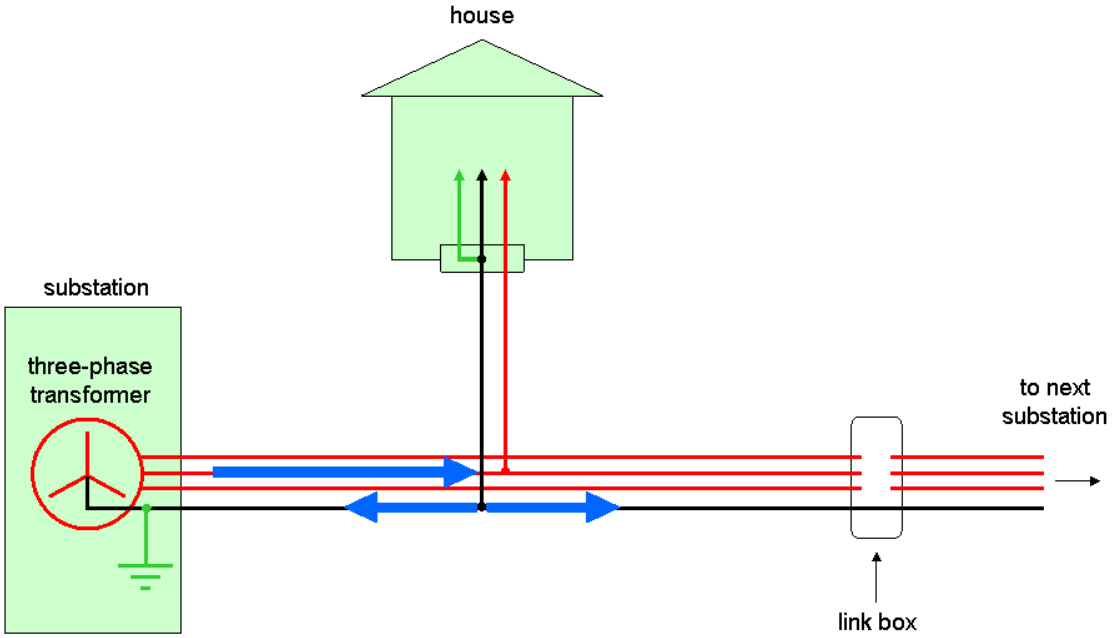
- Broken neutral conductors can exist for long periods undetected as the system still works
  - They may produce flickering of lights which is how we usually spot them
- They are a safety hazard and we want to identify and repair them when we can
- The neutral may not actually be broken, it may just be high impedance
  - Produces the same effect, of more neutral current diverting
  - High impedance may be a precursor to breaking altogether

An additional issue:
Link boxes



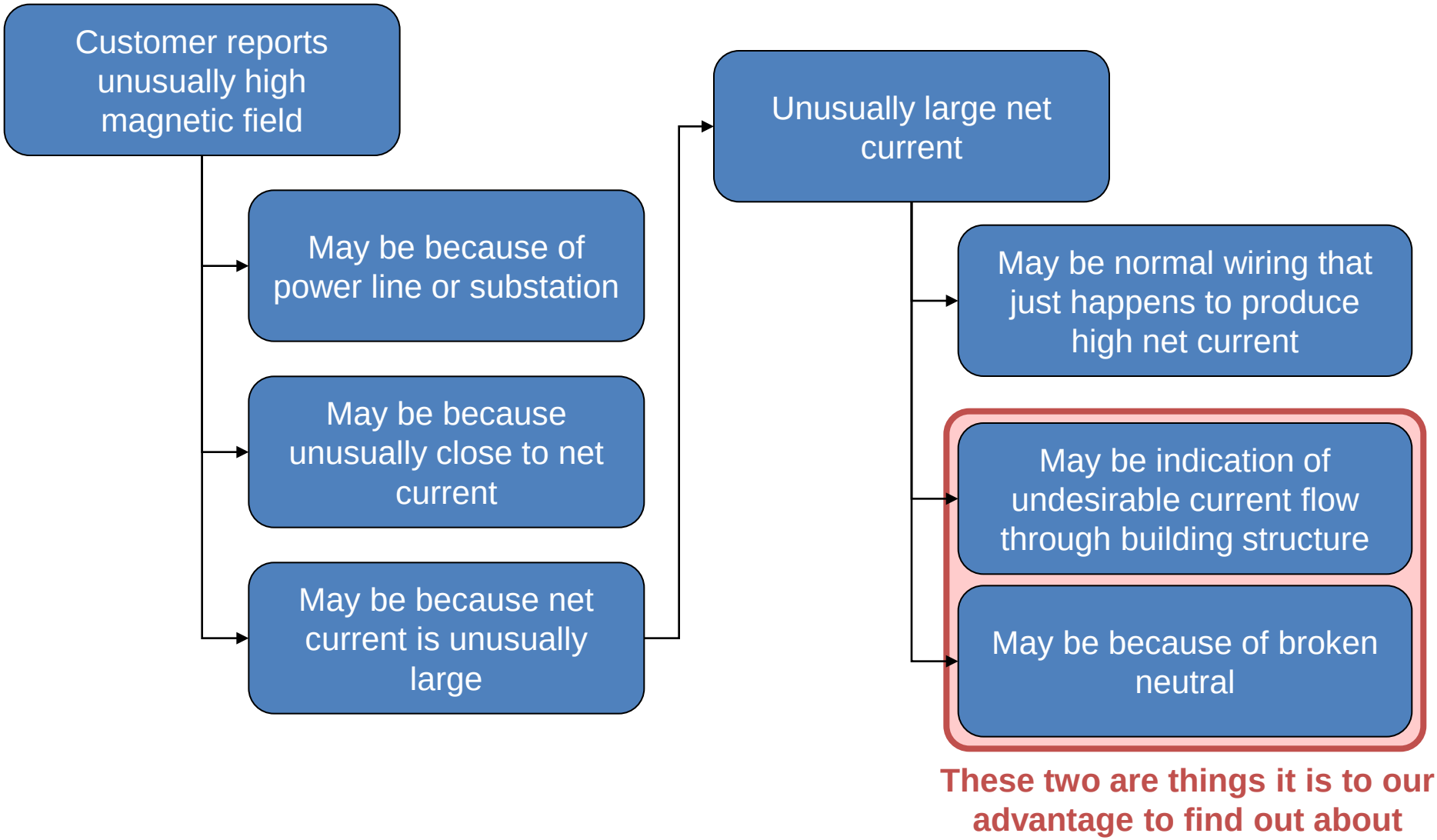
- The ends of adjacent circuits may be joined at a link box
- Most DNOs routinely leave neutral links in

Link boxes: consequences



- Creates another way for neutral current to go in a different cable to the load current
- May be a low-impedance path so may create high net current
- Nothing inherently wrong with this but undesirable to have current too high

Summary


Customer reports unusually high magnetic field
May be because of power line or substation
May be because unusually close to net current
May be because net current is unusually large
Unusually large net current
May be normal wiring that just happens to produce high net current
May be indication of undesirable current flow through building structure
May be because of broken neutral
These two are things it is to our advantage to find out about

How high is high?

Unfortunately there is no hard and fast answer!

- 0.2 µT: top end of the normal range of fields in homes – unlikely to be an indication of anything untoward
- 0.4 µT: rarer – 1 in 500 homes have fields this high from net currents – may be nothing untoward but worth exploring
- 1 µT: more likely to be an indication that something may be wrong

Remember these are the background field, not high values near appliances

The legal position

- The only formal requirement is to comply with the exposure limits
  - Limit 360 µT (reference level 100 µT)
  - No distribution circuit will ever produce fields this high
- We have agreed to follow best practice
  - Set out in Engineering Recommendation G92 2013
  - Best practice includes taking customer concerns seriously and eliminating any obvious problems
- If there is no actual fault (e.g. broken neutral), there is no legal requirement on us to take action to reduce fields.

But....

A twin track

- We take customer reports of high fields seriously because it is good customer relations

But also

- We take customer reports of high fields seriously because they may point us to a network problem we would not otherwise have been aware of

What happens inside the home?

- This presentation focuses on issues with distribution wiring outside the home
  - Multiple earthing of neutral
  - Alternative paths for neutral currents
  - Broken neutrals
- Similar issues can also occur with the wiring inside the home

To skip the next few more technical slides, go to slide 37

Examples of wiring problems inside the home

- Faulty ring main
  - Phase current flows one way round ring, neutral current the other way
- Two-way switching of lights
  - Can result in large loops of current if the electrician took short cuts
- Accidental extra earth connections to the neutral
  - Through corroded insulation or a screw cutting the insulation
- Incorrect wiring
  - Someone wired the neutral and earth the wrong way round, or left a break in the neutral

Indications of these wiring problems inside the home

- All of these wiring problems tend to produce an elevated magnetic field:
  - Particularly in the area of the home where the problem is, rather than the whole home as is usually the case when the source is outside the house
  - That changes quite obviously as particular loads are switched on or off

Note: increasingly homes are fitted with Residual Current Devices (RCDs) which would trip in the presence of some, but not all, of these problems

Our response to wiring problems inside the home

- Advise the customer to consult an electrician

Other issues
not covered in this presentation

- Detailed information about net currents
  - There is a wealth of information about magnitudes, time variation etc at www.emfs.info
- Fields from substations
  - We have signed up to Best Practice in Engineering Recommendation G92 and this has some implications for substations
- The science of EMFs and how to address public concern
  - Again see www.emfs.info or your own company's training

What to do with reports of high fields

PLACEHOLDER

- Company specific – each company add its own internal procedures here.

For further information

- www.emfs.info or National Grid's Helpline 08457 023270
- Your own company's EMF experts
- The ENA Safety, Health and Environment Department

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