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<tr><td colspan="2">Document Title:<br>Description,<br>AN, Underground power cable installations Soil thermal resistivity</td><td colspan="2">Part # and Rev.<br>13476-00</td></tr>
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**Production Filename:** 13476 (In Product Library)

**Path to Working Files:** DecaDoc\Application Notes\Master

**Dimensions:** 8.5 inch wide, 11 inch tall

**Material:** Paper, 92 Bright White or better, 75g/m² or heavier

**Colors:** Color Print on White

**Printer:** HP Color LaserJet 8550-PS

**Finish:** None

**Adhesive:** None

**Special Notes:** Illustrations are Ref Only ** Not to Scale ** (Shown page 1 of 4)

DECAGON DEVICES Application Note

## Underground Power Cable Installations: Soil Thermal Resistivity

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Campbell, G., and Bristow, K. (2002). Soil thermal resistivity. Australian Power Transmission and Distribution. Chapel Hill, Qld :PTD Publications: 46-48.

**Who would have thought that an electrical power engineer would need to be an expert at soil physics as well?** But, increasingly, such knowledge is becoming critical in the design and implementation of underground power transmission and distribution systems. The issues are simple enough. Electricity flowing in a conductor generates heat. A resistance to heat flow between the cable and the ambient environment causes the cable temperature to rise. Moderate increases in temperature are within the range for which the cable was designed, but temperatures above the design temperature shorten cable life. Catastrophic failure occurs when cable temperatures become too high, as was the case in Auckland, NZ in 1998. Since the soil is in the heat flow path between the cable and the ambient environment, and therefore forms part of the thermal resistance, soil thermal properties are an important part of the overall design.

The detailed calculations needed to correctly design an underground cable system have been known for over 60 years. The procedures typically used are outlined in Neher and McGrath (1957), and, more recently by the International Electrotechnical Commission (1982). These calculations can be done by hand, but most engineers now use either commercial or home-brew computer programs. The calculations are quite detailed, and are generally based on sound physics or good empiricism, until one gets to the soil. Then the numbers chosen often are almost a shot in the dark. Since, even in a well-designed system, the soil may account for half or more of the total thermal resistance, engineers need to treat that part with as much respect as they do the cables and ducts.

### Thermal Resistivity of Soil

Good theories describing thermal resistivity of soil have been around for a long time (de Vries, 1963; Campbell and Norman, 1998). These models are based on dielectric mixing models, and treat the overall resistivity as a weighted parallel combination of the constituent resistivities. Five constituents are important in determining the thermal resistivity of soil. These are quartz, other soil minerals, water, organic matter, and air, in order of increasing resistivity. The actual values for these materials are 0.1, 0.4, 1.7, 4.0, and 40 m C/W. Without knowing anything about the weighting factors for these in an actual soil or fill material, four things should be clear:

1) Air is bad. Fill must be tightly packed to minimize air space, in order to achieve acceptably low thermal resistances.

2) Replacing air with water helps a lot, but water is still not a very good conductor.

3) Organic matter, no matter how wet, will still have a very high resistivity.

4) Fill materials high in quartz will have the lowest resistivity, other things being equal.

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