DEVELOPMENT OF A SOFTWARE PACKAGE FOR CALCULATING CURRENT RATING OF MEDIUM VOLTAGE POWER CABLES

A Thesis presented to
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BY

D.G.A.K. Wijeratna

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Project Supervisors: Prof. J.R. Lucas, Dr. J.H.C. Peiris, Dr. H.Y.R. Perera

ABSTRACT

CableAmp, a Windows based software has been developed to calculate the cable ampacity of medium voltage power cables laid in free air or directly buried in the ground. The highly graphical user interface allows easy usage. The user inputs the required data of the cable design as well as the cable installation method. CableAmp then calculates the continuous current rating (at 100% load factor) of the power cables laid in free air or directly buried in the ground. It is applicable to extruded solid insulation, rated from 6 kV to 33 kV. An increased peak current rating, called the cyclic current rating, can also be obtained from the software package for a specified load profile. The calculation procedure is in accordance with International Standard IEC 287.

The report presents the theory for the software, and also validates the results obtained by the software by comparison with manufacturers current ratings for standard cables.

DECLARATIONS

I certify that this thesis has not been previously prepared in whole or part to any University or Institution for a higher degree.

A.K. Wijeratna

D.G.A.K. Wijeratna
December 2002

UOM Verified Signature

Prof J.R.Lucas
Supervisor

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CableAmp, a Windows based software has been developed to calculate the cable ampacity of medium voltage power cables laid in free air or directly buried in the ground. The highly graphical user interface allows easy usage. The user inputs the required data of the cable design as well as the cable installation method. CableAmp then calculates the continuous current rating (at 100% load factor) of the power cables laid in free air or directly buried in the ground. It is applicable to extruded solid insulation, rated from 6 kV to 33 kV. An increased peak current rating, called the cyclic current rating, can also be obtained from the software package for a specified load profile. The calculation procedure is in accordance with International Standard IEC 287.

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TABLE OF CONTENTS

List of Figures

LIST OF SYMBOLS

A	Cross sectional area of the armour	(mm^2)
C	Capacitance per core per unit length	(F/m)
D	Mean diameter of the sheath/screen	(mm)
Da'	External diameter of the armour	(mm)
D_c	External diameter of cable	(m)
D_i	External diameter of insulation	(mm)
Doc	The diameter of imaginary coaxial cylinder which just touches the crest of a corrugated sheath	(mm)
Dit	The diameter of imaginary coaxial cylinder which just touches the inside surface of troughs of a corrugated sheath	(mm)
D_s	External Diameter of sheath	(mm)
F	Coefficient defined in 5.1.7.1	
H	Intensity of solar radiation	(W/m^2)
I_{cont}	Continuous current in one conductor	(A)
I_{cyclic}	Cyclic current in one conductor	(A)
L	Distance from the surface of the ground to the cable axis	(mm)
N	Number of conductors in the cable	
P, Q	Coefficient defined in 5.1.5	
R	a.c. resistance of conductor at maximum operating temperature	(Ω/m)
R'	d.c. resistance of conductor at maximum operating temperature	(Ω/m)
R_A	a.c. resistance of armour at maximum armour temperature	(Ω/m)
R_0	d.c. resistance of conductor at 20^0c	(Ω/m)
R_s	The resistance of sheath or screen per unit length of cable at its maximum operating temperature	(Ω/m)
T_1	Thermal resistance between the conductor and sheath	(K.m/W)
T_2	Thermal resistance between sheath and the armour	(K.m/W)
T_3	Thermal resistance of the outer serving	(K.m/W)
T_4	Thermal resistance of the surrounding medium	(K.m/W)
U_0	Voltage between conductor and screen or sheath	(kV)
W	Total joule losses per cable at maximum operating temperature	(W/m)
Wd	Dielectric Loss per unit length per phase	(W/m)
X	The reactance and resistance per unit length of the sheath or screen per unit length of cable	(Ω/m)
X_m	Mutual reactance per unit length of cable between sheath of an outer cable and the conductors of the other two	(Ω/m)
c	Distance between the axis of one conductor and the axis of the cable	(mm)
d	Mean diameter of sheath or screen	(mm)
d_A	Mean diameter of the armour	(mm)
d_d	External diameter of insulation	(mm)
d_c	External diameter of conductor (Including screen if any)	(mm)
f	System frequency	(Hz)
h	Heat dissipation coefficient	
k_p	Factor used in calculating x_p(proximity effect)	
k_s	Factor used in calculating x_s(skin effect)	
r_f	Radius of the circle circumsbring the two sector shaped conductors	(mm)
s	Distance between conductor axes	(mm)

t	Thickness of insulation between conductors	(mm)
t_1	Thickness of insulation between conductor and sheath	(mm)
t_2	Thickness of bedding	(mm)
t_3	Thickness of the outer serving	(mm)
t_s	Thickness of sheath	(mm)
y_s	Skin effect factor	
y_p	Proximity effect factor	
λ_1	Sheath loss factor	
λ_2	Armour loss factor	
θ	Maximum operating temperature	(^{0}C)
$\Delta\theta$	Temperature difference	(K)
$\Delta\theta s$	Excess of cable surface temperature above ambient temperature	(K)
$\theta(\infty)$	Conductor steady state temperature rise above ambient	(K)
σ	Absorption coefficient of solar radiation for the cable surface (This value is taken as 10^3 for most latitudes)	
δ	Equivalent thickness of armour ($A/(\prod d_A)$	(mm)
δ_1	Soil thermal diffusivity (taken as $0.5*10^{-6}$ m^2/s)	
ω	Angular frequency of the system ($2\prod f$)	
ε	The relative permitivity of insulation	
α_{20}	Constant mass temperature coefficient at 20^0c per Kelvin	(1/K)
μ	Relative permitivity of the steel tape (Usually taken as 300)	
ρ_s	Electrical resitivity of sheath material at operating temperature	(Ωm)
ρ_{T1}	Thermal resitivity of insulation	(K.m/W)
ρ_{T2}	Thermal resitivity of bedding material	(K.m/W)
ρ_{T3}	Thermal resistivity of outer serving material	(K.m/W)
ρ_{T4}	Thermal resistivity of soil	(K.m/W)