**NOMENCLATURE**:

|  |  |
| --- | --- |
| **Abbreviations:** | |
| DS | Distribution System |
| ENS | Energy not supplied |
| FL | Fault Location |
| FLA | Fault Location Algorithm |
| GA | Genetic Algorithm |
| IC | Investment Cost |
| OF | Objective Function |
| IRR | Internal rate of return |
| OPP | Optimal Placement of *u*PMUs |
| PMU | Phasor Measurement Unit |
| RVNS | Reduced Variable Neighborhood Search |
| SAIDI | System Average Interruption Duration Index |
| SE | State Estimation |
| SP | Shortest Path |
|  | Micro-Phasor measurement Unit |
| WMR | Weighted Measurement Residual |
| **Sets:** |  |
|  | Set of nodes that make up the SP |
|  | Set of lines belonging to section |
|  | Set of nodes belonging to branch |
|  | Set of sections that, when in contingency, affect section |
|  | Set of customer types |
|  | Set with the *u*PMUs locations |
|  | Set of all system nodes |
| **Indices:** | |
|  | Index of segment |
|  | Index of a section that, when in contingency, affect section |
|  | Index of section |
|  | Index of customer types |
|  | Index of the buses or nodes |
|  | Index of distribution lines |
|  | Index of predecessor node |
|  | Index of current node |
|  | Indexes of branches that originate at a node |
|  | Measuring time |
|  | Time at which the fault occurs |
| **Parameters:** | |
|  | Years of useful life |
|  | Variance of the measurement |
|  | Interest rate |
|  | Error due to measurement noise |
|  | Line  fault rate |
|  | Fault rate of line belonging to section |
|  | Average value of each residual |
|  | Annualized cost per kWh not supplied for a c-type consumer |
|  | Cost per kWh not supplied for a c-type consumer |
|  | *u*PMU cost |
|  | Number of monitored buses |
|  | Permanent faults factor of section |
|  | Mathematical relation between measurements and states |
|  | Matrix considering topological variations when assuming a fault on line |
|  | Relation between the estimation and the measurement current vector |
|  | Relation between the estimation and the measurement voltage vector |
|  | Current injected into the node |
|  | Imaginary component of the three-phase line current leaving node |
|  | Real component of the three-phase line current leaving node |
|  | Kilometers of optical power ground wire required to connect all *u*PMUs |
|  | Length of line |
|  | Length of line |
|  | Average annual demand of customers with type of section |
|  |  |
|  | Line , belonging to section |
|  | Number of lines |
|  | Number of buses |
|  | Max number of neighborhoods of each iteration |
|  | Number of samples of |
|  | Number of sections |
|  | Number of customers of the feeder |
|  | Number of customers of section |
|  | Maximum number of generations for GA |
|  | Maximum number of iterations for RVNS algorithm |
|  | Neighborhood of |
|  | Optimal number of *u*PMUs identified by the algorithm |
|  | Number of tournaments |
|  | Max number of *u*PMUs |
|  | Number of *u*PMUs |
|  | Repair time |
|  | Crossover rate |
|  | Mutation rate |
|  | Measurement covariance matrix |
|  | Population size |
|  | Preparation time of maintenance crews |
|  | Time of FL in section without the presence of *u*PMUs |
|  | Time of FL in segment of section |
|  | Repair time of section |
|  | Graph node |
|  | Function that allows obtaining the present value of the ENS cost |
|  | Imaginary component of the three phase-to-ground voltage of node |
|  | Real component of the three phase-to-ground voltage of node |
|  | Mean residual , obtained when there is no system failure |
|  | Three-phase admittance matrix |
|  | Measurement vector at time |
|  | Measurement vector obtained assuming a fault on line |
|  | Vector of unknown parameters that will be obtained from |
|  | Vector of current measurements |
|  | Vector with parameters measured directly by the *u*PMUs |
|  | Vector of voltage measurements |
|  | Three-phase impedance matrix of line |
| **Variables:** | |
|  | Fault rate of section |
|  | Number of side branches originating at node |
|  | Current injection at node |
|  | Current leaving the predecessor node |
|  | Current leaving the current node |
|  | Current that is injected into the side branch of node |
|  | Residual with the least deviation from its mean value |
|  | Residual with the least deviation obtained assuming a fault on line |
|  | Faulted line identified by FLA |
|  | Number of segments of section |
|  | Probability of a fault occurring in the set of lines of section |
|  | Lateral branch that originates at node , |
|  | FL time in section , which depending on the *u*PMUs position |
|  | Average time to locate a fault in section |
|  | Estimated time to locate a fault in section |
|  | Time to locate a fault on the line of section |
|  | node |
|  | Voltage of node |
|  | Predecessor node voltage |
|  | Current node voltage |
|  | Weighted measurement residual at time and with the virtual bus in the middle of line |
|  | Weighted measurement residualof iteration |
|  | Estimated state |
|  | State of a three-phase network, obtained at time and considering the virtual bus in the middle of line |
|  | Computing measurement vector, obtained assuming a fault on line |
|  | Unknown parameters vector |
|  | Three-phase impedance matrix of the line |