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Relay Protection Coordination Integrated Optimal Placement and Size OFDG

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ABSTRACT

In this paper presents a methodology for optimal placement and sizing of DG with due consideration to relay coordination is proposed here. The impact analysis of the numberof DGs, their locations and capacities upon short circuit currents will be done so that an optimal DG placement to maximize the penetration level of DG in distribution networks without changing the original relay protection schemes is obtained. Genetic Algorithm (GA) is used for finding the optimal location and sizing of DG in Distribution Networks. Simulation studies have been carried out on a radial test distribution network to verify the effectiveness the proposed system.

Keywords: Distributed generation (DG), appropriation network, genetic Algorithm (GA), ideal position, ideal estimating, and transfer protection.

I. INTRODUCTION

The Pursuit of maintainable, clean, and effective vitality advancement, the consistently expanding requirement for electrical power generation, and tight requirements over the development of new transmission lines for long separation control transmission have made expanded interests in distributed generation (DG). DG frameworks or sources (DGs) are measured in structure and less exorbitant to assemble, regularly put at the appropriation level at or close load focuses, and are little in estimate (with respect to the power limit of the framework in which they are set). Whenever possible, DGs can be deliberately set in circulation systems for matrix support, lessening power misfortunes and on-crest working expenses, and enhancing voltage profiles and stack factors. Be that as it may, if not very much oversaw, DGs can likewise expedite antagonistic affects the circulation systems, especially the security transfers in the framework where they are introduced. Customarily, a dispersion organize comprises of outspread feeders with a solitary age source (i.e., the substation), which is furnished with current insurance gadgets at the circuit breakers (CBs) in the substation. After the establishment of DGs, the customary spiral circulation organize has different age sources. The changed extents and bearings of short circuit streams may prompt false and disappointment activities in insurance transfers that are designed for the first framework without DGs. Broad research has been done on the position and measuring of DGs with different target capacities, for example, lessening of energy misfortune, voltage profile change, and in addition lessening of operational cost and ecological impacts. Awesome surveys on the models, techniques, and the future research needs have been condensed. By the by, little exertion has been done on the ideal arrangement of DGs while thinking about the transfer assurance, which is additionally prove by the exhaustive review papers. Another control procedure to moderate the effect of DGs on insurance framework was considered. A technique to decide the most extreme admissible limit of a DG considering voltage, misfortune, and protection. The appropriation systems with one, two, or on the other hand three DG sources at various areas were talked about. Utilizing the PSCAD, the effects of DG on feeder assurance wit superconducting flaw current limiter was examined. The impact of high DG infiltration on defensive gadget coordination was investigated and a versatile assurance conspires as an answer for the issues recognized was proposed. The sort, position and the limit of DG was talked about in on how symphonious substance and security working circumstances are influenced by DGs. This paper introduces an ideal DG arrangement and estimating strategy while considering the transfer insurance so the penetration level of DG will be boosted without evolving the first arrangement of hand-off assurance framework. The hamper are computed under various DG limits also, areas. Genetic algorithm (GA) is utilized to settle the improvement issue while the prerequisites forced by the first hand-off framework on reasonable short out streams are dealt with as the requirements in the streamlining procedure. The proposed strategy is checked on a broadly utilized three-feeder test appropriation arrange and a broadly utilized 33-hub test framework. The rest of this paper is sorted out as takes after. Area II talks about the effects of DG upon the dissemination arrange hand-off assurance by means of illustrative cases.

II. IMPACT OF DG ON DISTRIBUTED NETWORK RELAY PROTECTION

At the point when DGs are added to a distribution network, the current/ power streams turn out to be more confounded under both ordinary what's more, blame conditions because of the various sources in the network [18]. It is imperative and important to break down the effects of DGs on the selectivity, affectability, and dependability of the first hand-off insurance arrangement. In this area, illustrative cases are given for a straightforward framework (some portion of a genuine circulation organizes in Chongqing, China) of Fig. 1 when DGs are introduced at various hubs. Through the illustrative cases, the effects of DG on the blame streams at various areas are investigated for various DG limits. The case dissemination arrange in Fig. 1 has two 10.5 kV feeders and a short out limit of 200 MVA with a framework

Comparable impedance (Zs) of 0.5 p .u. Lines L1, L2, L3, L4, and L6 are all a similar kind overhead lines at a length of 4, 4, 5, 5, and 4 km, individually.

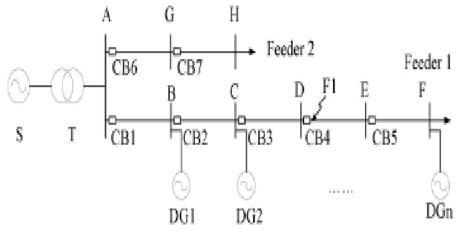

Fig. 1. Case two-feeder dispersion system with DGs introduced protection and reactance

per unit length of the overhead line are r1 = 0.27 /km also, x1 = 0.347 /km. Lines L5 and L7 are underground links at a length of 10 and 6 km, individually. The protection also, reactance per unit length of the underground link are r1 = 0.259 /km and x1 = 0.093 /km. The heap at every hub is 6 MVA with a power factor of 0.85 slacking. The hand-off insurance arrangements for these lines are immediate over-current security and clear time over-current insurance. The hand-off settings are given in Table I. In the table, II operation is the prompt over-current security setting esteem, also, IIII operation is positive time over-current security setting esteem. With the end goal of representation, take feeder 1 in the framework for instance and consider only one DG introduced a

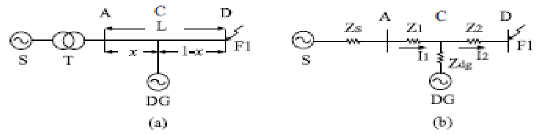

Fig. 2. Equal circuit of a conveyance feeder with a DG introduced.

(a)Distributed system with a single DG. (b) Equivalent circuit.hub C.

Fig. 2 demonstrates the comparable circuit of the feeder to figure hamper when blame happens at areaF1 (i.e., hub D). The separation between the blame area and the substation is L, and L = L1+L2+L3 with an aggregate impedance of Z. Note that the part (i.e., L4 and L5) after the blame area F1 isn't appeared in Fig. 2. Since L1, L2, and L3 are the same compose electrical cables, the DG area can be spoken to by an area factor x, i.e., the separation between the substation what's more, the DG area is x × L and the relating line impedance is Z1 = x × Z, appeared in Fig. 2. Zs is the framework comparable impedance and Z2 is clearly (1 − x) × Z. The effects of DG on the upstream blame current (I1) and downstream blame current (I2) are unique. It can be promptly checked that the upstream blame current is debilitated while the downstream blame current is fortified. The abatement (or increment) in blame streams can cause transfers inability to trip (or false stumbling). To delineate the two kinds of effect on blame streams because of DG, the DG in Figs. 1 and 2 is expected to be a voltage wellspring of 1 p.u. behind an arrangement impedance Z dg, dg is the sub transient reactance of the DG and SB is the base MVA (i.e., 100 MVA in this paper) and Sdg is the limit of the DG.

III. RELAY PROTECTION INTEGRATED DG OPTIMALSIZING AND PLACEMENT

The reconciliation of DG muddles the insurance setup in dissemination arranges and may bring about false stumbling and additionally neglect to trip transfers. Keeping in mind the end goal to address these issues, anothehand-off security incorporated ideal DG position and estimating strategy is proposed in this paper. The goal is to boost DG limit however many as would be prudent while without influencing the current hand-off security. The necessities forced by the current hand-off plan on permissible short out streams are dealt with as the requirements in the improvement plan. GA is utilized to locate the ideal DG situation and estimating.

A. Short-Circuit Currents in the Distribution Network with DG Connected

In conventional circulation systems comprising of outspread feeders, it is advantageous to compute the short out current of each branch and the present stream is unidirectional, i.e., from the source (the substation) to the heap. Be that as it may, when DGs are introduced, the various sources in the dispersion arrange will change the short out current size as well as additionally headings. As examined in the past segment, the limits what's more, the areas of DG can impact sly affect the short out streams. In this segment, the superposition strategy is used to ascertain the short out streams in a run of the mill dispersion coordinate with different DGs associated. The technique is easy to utilize and simple to actualize. In the superposition technique, a blame condition of a conveyance arranges is made out of two sections, i.e., the typical segment what's more, the added substance blame segment. The typical part alludes to the state without blame in the framework, and the added substance blame segment centers around the effect of short out current. On the off chance that Z is the hub impedance framework in the framework without DGs, when a DG is associated with hub k, a branch between hub k and ground is included into the framework. This expansion will not change the general number of hubs and the request of the hub impedance network. Be that as it may, all the impedance components in the network should be refreshed utilizing the accompanying branch
Expansion recipe:

$$Z_{ij,\text{new}} = Z_{ij} - \frac{Z_{ik} \times Z_{kj}}{Z_{kk} + jx_{\text{dg}k}} \qquad (2)$$

Where x dgk is the comparable generator impedance related with the DG; Zij, Zik, and Zkj speak to the common impedance between hubs I and j, hubs I and k, and hubs k and j, separately; Zij ,new signifies the new shared a great many change. For a system with numerous DGs, the comparing hub impedance framework Z new including DGs can At the point when a three-phase to ground blame happens at node f, the added substance blame part of the voltage vector is

$$\begin{bmatrix} \Delta\ \dot{V}_1 \\ \vdots \\ \Delta\ \dot{V}_f \\ \vdots \\ \Delta\ \dot{V}_n \end{bmatrix} = \begin{bmatrix} Z_{11} & \cdots & Z_{1f} & \cdots & Z_{1n} \\ \vdots & \ddots & & & \\ Z_{f1} & & Z_{ff} & & Z_{fn} \\ \vdots & & & \ddots & \\ Z_{n1} & & Z_{nf} & & Z_{nn} \end{bmatrix} \cdot \begin{bmatrix} 0 \\ \vdots \\ -\dot{I}_f \\ \vdots \\ 0 \end{bmatrix}. \quad (3)$$

It is noticed that for rearrangements the subscript "new" associated to the impedance image Z has been overlooked from that point. Utilizing (3) to get the added substance voltage changes, the hub voltage under disappointment condition is

$$\dot{V} = \dot{V}_0 + \Delta\ \dot{V}. \quad (4)$$

In cut off, it is generally accepted hub voltage is equivalent to 1.0 p. u. under ordinary conditions. Along these lines, (4) can be streamlined as

$$\dot{V} = 1 + \Delta\ \dot{V}. \quad (5)$$

The branch fault currents are

$$\dot{I}_{ij} = \frac{\dot{V}_i - \dot{V}_j}{Z_{ij}} \quad (6)$$

where Zij is the impedance of the branch associating hubs I what's more, j when DGs are introduced.

B.DG Optimization Problem Formulation with Relay Protection Integrated

The impact of DGs on cut off is reliant on the limits and areas of DGs and the short out focuses in the framework. Along these lines, the short out streams are when all is said in done elements of the limits and areas of DGs, the topology and parameters of the dispersion organize, as well as the spots of short out issues, given as

$$I = f(z, s_{dg}, F) \quad (7)$$

where I speaks to the branch streams under short out blame condition; z speaks to the structure and parameters of the appropriation arrange, sdg is the DG limit vector, and F contains the data of short out blame, for example, blame sort and blame area. On the off chance that there is no DG at hub j, the relating vector thing is zero, i.e., sdg ,j = 0. Keeping in mind the end goal to stay away from any adjustments to the current transfer insurance framework, the accompanying conditions must be fulfilled. At the point when a short out blame occurred toward the finish of the contiguous branch downstream of a DG hub,

So as to maintain a strategic distance from any adjustments to the current transfer insurance framework, the accompanying conditions must be fulfilled.

(1)When a short out blame occurred toward the finish of the nearby branch downstream of a DG hub, the decline of affectability in upstream insurances ought not prompt disappointment tasks (i.e., neglect to trip) in transfers, which can communicated as

$$I_i^{(2)}(z, s_{dg}, F) > I_{op,i}^{III} \quad i = 1, 2 \ldots n \quad (8)$$

where I(2)

I (z, sdg ,F) is the two-stage impede

on branch I, IIII op,i is the setting of unequivocal time over-current transfers for the ith branch, and n is the number of upstream branches.

2) When a short out blame happens toward the finish of the nearby branch downstream of a DG hub, the expansion of affectability in downstream assurances ought not prompt false stumbling in transfers, that is

$$I_i = f(z, s_{dg}, F) < I_{op,i}^{I} \quad i = 1, 2 \ldots m \quad (9)$$

where Ii = f (z, sdg ,F) is the three-stage cut off streams on branch I, II op,i is the setting of quick over-current transfer for the ith branch, and m is the number of downstream branches.

3) When a short out blame occurred on an adjoining feeder, the turn around streams from DGs to the blame point ought not bring about false stumbling of the transfer of the ordinary line where the DG is introduced, that is

$$I_i^r(z, s_{dg}, F) < I_{op,i}^{I} \quad i = 1, 2 \ldots l \quad (10)$$

where Iri (z, sdg,F) is the three-stage switch cut off current on branch I, II op, i is the setting of prompt over current transfers on the I the branch, and l is the number of branches which have switch current streams.

4) moreover, keeping in mind the end goal to be more reasonable, two kind of DG limit confinements are considered too, counting the decline of affectability in upstream assurances ought not prompt disappointment tasks (i.e., neglect to trip) in transfers, which can communicated furthermore, keeping in mind the end goal to be more viable, two kind of DG limit restrictions are considered too, counting:

a) restriction of aggregate DG limit, that is

$$\sum_{j=1}^{n} s_{dg,j} \leq T_{max}; \quad (11)$$

b) Restriction of every DG limit, that is

$$s_{dg,j} \leq S_{max,j} \quad j = 1, \ldots, n \quad (12)$$

where T max and Sam x ,j show the aggregate passable DG bondage constrain and the limit furthest reaches of the jth single DG, individually.

$$\max(s_{dg1} + s_{dg2} \ldots s_{dgn}) \quad (13)$$
$$\text{subject to (8)–(12).}$$

C. Genetic Algorithm-Based Optimization Algorithm Implementation

In this paper, GA is utilized to take care of the advancement issue . GA has been utilized as a part of numerous unpredictable applications because of its amazing benefits, for example, parallel processing, arbitrary look, and versatile enhancement. GA can be utilized to handle the improvement of various people in a gathering in the meantime by utilizing choice, hybrid, and change activities to look for the ideal arrangement in the arrangement space .

(1)Fitness Associated With the Objective Function: As previously mentioned, our improvement objective is to expand the aggregate DG limit while without changing the current hand-off assurance, as given in (13). In like manner, the wellness to assessing people in the populace can be characterized as

$$\text{fitness} = s_{dg1} + s_{dg2} \ldots s_{dgn}. \quad (14)$$

2) Encoding: The physical areas and limits of DGs ought to be changed over to the suitable factors which can be managed inside the GA. Without loss of all inclusive statement, it is accepted that an aggregate of n DGs will be introduced in an appropriation organize what's more, the limit factors of the n DGs are communicated as far as sdg1, . . . , sdgi . . . sdgn. In the event that there is no DG at hub I, at that point sdgi = 0; generally, sdgi = 0. Twofold, decimal, and representative coding plans are regularly used to change over genuine factors into the GA portrayal [31]. In this paper, decimal coding is utilized.

3) GA Operations: The measure of individual populace (M) in GA is a vital factor influencing the proficiency and result of enhancement. Too little a populace can't guarantee the decent variety of populace and the improvement frequently falls into neighborhood ideal. Then again, if M is too huge, it will result in substantial calculation weight and low effectiveness. In this paper, M is hence set as 300. As needs be, hybrid rate is 0.7 and change rate is 0.02.

The accompanying advances are taken in the GA strategy.

1) Data Input: Distribution organize topology, line impedances and hand-off settings.

2) Initialization: countless (000 in this paper) singular DG limit/area mixes are arbitrarily created as the underlying populace of DGs and checked to fulfill the limitations of over current insurances. For example, in Fig. 1, if DGs are permitted to put on 5 hubs (B, C, D, E, G), a qualified individual Dg

3) Selection: The relative determination is utilized on the current populace pop(t) to get the people to come populace pop.

4) Crossover: One-point hybrid system is connected on pop to produce the second era of populace pop (t)

$$\mathrm{pop}'(t)_1 = S_{dgB}(0.5), S_{dgC}(0.4) \,\vdots\, S_{dgD}(0.7), S_{dgE}(0.8), S_{dgG}(0.3)$$
$$\mathrm{pop}'(t)_2 = S_{dgB}(0.4), S_{dgC}(0.6) \,\vdots\, S_{dgD}(0.8), S_{dgE}(0.5), S_{dgG}(0.4)$$

Crossover point

$$\mathrm{pop}''(t)_1 = S_{dgB}(0.5), S_{dgC}(0.4) \,\vdots\, S_{dgD}(0.8), S_{dgE}(0.5), S_{dgG}(0.4)$$
$$\mathrm{pop}''(t)_2 = S_{dgB}(0.4), S_{dgC}(0.6) \,\vdots\, S_{dgD}(0.7), S_{dgE}(0.8), S_{dgG}(0.3)$$

5) Mutation: The uniform transformation task is utilized to produce the third era of populace pop

(t) from pop (t, for example,

$$\mathrm{pop}'''(t) = S_{dgB}(0.4), S_{dgC}(0.6), S_{dgD}(0.7), S_{dgE}(0.8), S_{dgG}(0.3)$$

$\downarrow$ Mutation

$$\mathrm{pop}'''(t) = S_{dgB}(0.4), S_{dgC}(0.8), S_{dgD}(0.7), S_{dgE}(0.8), S_{dgG}(0.3).$$

6) Check whether the people in pop (t) fulfill the assurance imperatives. Provided that this is true, the qualified people will be kept in the people to come; else, they will be disposed of.

IV. SIMULATION STUDIES

A. Fourteen node system

The proposed optimization method for DG sizing and placement has been first verified on a three-feeder test distribution network as shown in Fig.5.1. Two situations of deploying DGs on all the nodes and selected nodes are studied. The system is a radial distribution network, including three feeders, 14 nodes, and 13 branches [28]. Total real and reactive power loads of the network are 28.7 MVA and 7.75 MVAR. The relay settings of the test distribution network (in P.U.) are given in TABLE.5.2. First, it is assumed that DG sources can be added to any node except the root node, i.e., node 1, which is connected to the substation.

Distribution network system

In order to meet the protection coordination requirements of the existing relay system even after the DGs installation, the fault constraints need to be checked with the values in TABLE. 5.2 Where I'_{op} is the setting value of the instantaneous over-current protection, andI'''_{op} is the setting value of definite time over-current protectionTABLE. .Relay settings of three-feeder distribution network

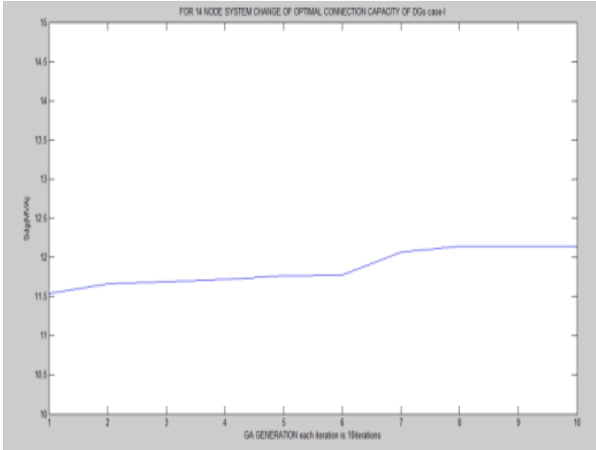

Figure 4. Change of optimal Capacity of DG for Case I

Table 1

Number	line	I'_{op}	I'''_{op}
CB1	1-2	1.9824	0.6099
CB2	1-3	1.9360	1.2706
CB3	1-12	1.9360	0.4122
CB4	2-5	1.5031	0.1976
CB5	2-6	1.6488	0.2400
CB6	5-7	1.4177	0.1412
CB7	3-8	1.6155	0.8019
CB8	8-9	1.3749	0.3501
CB9	8-10	1.3597	0.0565
CB10	3-11	1.5939	0.0960
CB11	4-11	1.5854	0.0875
CB12	12-13	1.6155	0.2344
CB13	13-14	1.513	0.1694

Table. 2. Optimal sizing and placement of each DG for case I

S.No	Node	DG Capacity
1	2	0.2659
2	3	0.8519
3	4	0.8136
4	5	0.7882
5	6	1.0626
6	7	0.1963
7	8	0.9736
8	9	2.6290
9	10	0.4820
10	11	0.3695
11	12	1.2442
12	13	0.8571
13	14	1.6230

The optimization process is shown in Fig. 5.2. The maximum allowable DG capacity is 12.1377 MVA. The optimal sizing and placement of each DG are given in TABLE. 5.3.

B. Fourteen node system Case II

Due to various practical constraints, not every node in the system can have DG installed. To consider this situation ,a second case study has been carried out for the scenario with selected nodes that are allowed to have DGs. The simulation study has been done for a scenario that only five nodes (i.e., nodes 6, 7, 10, 13, and 14) are selected to place DG sources. The DG sizing and locations are given in TABLE. 5.4 for this case. The optimization process isshowninFig.5.3. ThemaximumallowableDGcapacityis12.41 MVA.

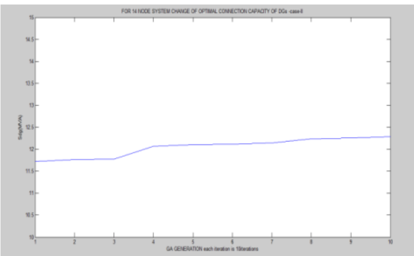

Figure 5. Change of optimal Capacity of DG for Case II

Table. 3. Optimal sizing and placement of each DG for case II

S.No	Node	DG Capacity
1	6	0.8747
2	7	2.8100
3	10	2.6745
4	13	2.5937
5	14	3.4861

C. Thirty Three node system

The 33-node test system [29], shown in Fig.5.4, is used to further verify the effectiveness of the proposed optimization method for DG placement and sizing .In this case only four nodes are allowed to install DGs, the DG sizing and placements are given in TABLE. 5.5, with a total DG capacity of 3.2354 MVA. The optimization Process is as shown in Fig.5.5.

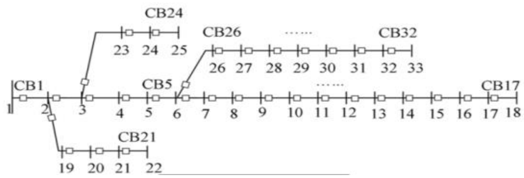

Figure 5. Thirty Three Node distribution network system

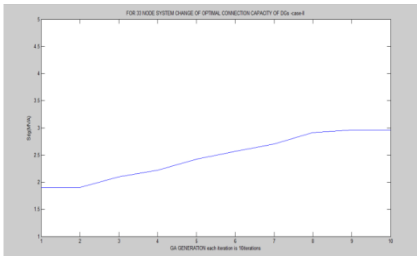

Figure 6. Change of optimal Capacity of DG for Thirty three node system

Table 4. Optimal sizing and placement of each DG for 33 node system

S. No	Node	DG Capacity
1	2	0.0623
2	6	0.5325
3	17	0.3640
4	24	0.3793

For the Fourteen Node system where the maximum allowable capacity of DG is set to 12.6 MVA

- The maximum allowable DG capacity for Case 1 Where DG is allowed to place at each node is 12.1377 MVA.
- For Case 2 where DG is allowed to place at only selected Nodes the maximum allowable capacity of DG is 12.41 MVA.

For the Thirty three Node system where the maximum allowable capacity of DG is set to 3.7 MVA For the Case where DG is allowed to place at only selected Nodes the maximum allowable capacity of DG is 2.957 MVA.

V. CONCLUSION

The integration of distributed generation (DG) sources can cause significant impacts on distribution networks, particularly the changes in magnitudes and directions of short circuit currents that may lead to false tripping or fail to trip over-current protection relays in the system. It is expensive and technically challenging to redesign/reconfigure and/or to replace the original protection system for a distribution network. If not appropriately handled, this issue can be a big hurdle before the wide use of DG.A relay protection integrated optimal DG placement and sizing method to maximize the penetration level of DG without changing the original relay protection system. Based on the impact analysis of the number of DGs, their locations and capacities upon short circuit currents, this project presents an optimal DG placement method to maximize the penetration level of DG in distribution networks without changing the original relay protection schemes. Genetic algorithm is used to find the optimal locations and sizes of DG in distribution networks. The proposed method has been verified on a widely used three-feeder test distribution network and a widely used 33-node distribution network to show the effectiveness of the proposed method .The simulation results under different scenarios show the effectiveness of the method.

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