

Voltage Regulators vs. Load Tap Changers

It appears to be rather simple: The basic function of an electrical utility is to supply power to its customers. Voltage to be supplied is defined within a pre-determined range.

Unfortunately, the laws of physics enter in, with system losses and voltage sags that must be corrected and regulated (in a technical sense) in order to stay within the voltage range. There are choices to be made in how to regulate voltage; some of these choices can require significant capital expenditures.

For many utilities, demand for electricity continues to grow. New demand must be met with increased supply. Demand Side Management and Distribution Automation look to utilize existing system resources more efficiently. Pay backs from lower system losses and deferred use of costly peak demand electricity justify purchases of new equipment. Modular designs are favored, using products optimized for their function. Future benefits would likely be realized in ease of repair and improved availability when replacement is needed.

Even in the real world of ongoing maintenance and occasional system or component failures, objectives of minimizing outage time and limiting equipment failures can be realized. The use of more simple, basic, modular products increases the potential for benefits in product availability, performance optimized in product function, and reduced concentration on large engineering design development. Modular equipment offers the flexibility of modeling each feeder to supply

service in an optimized range across most of the line or to the load center.

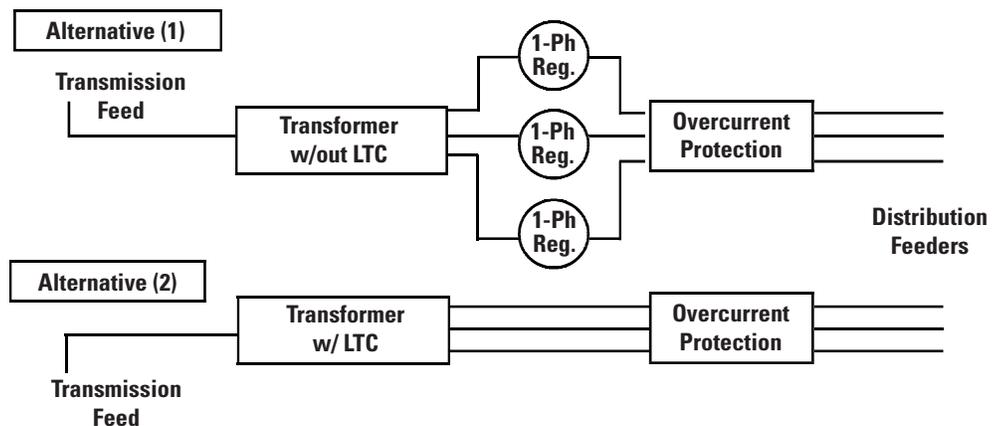
To meet today's needs, as well as anticipated future needs, utilities will be focusing their efforts to better utilize equipment already in place, and to carefully evaluate the inclusion of new equipment. Three factors to consider in a new equipment purchase decision are these:

- Expected utilization level of the equipment,
- Ease of use of the equipment, and
- Future maintenance schedules and anticipated repair rate.

As an example, in the purchase of equipment to regulate substation voltage, the following product alternatives may be considered (see Figure 1):

1. Single-phase Regulators in conjunction with a Transformer without a Load Tap Changer (LTC)
2. Single-phase Transformer with LTC in one package

Consider the common situation where equipment maintenance or failure requires taking the product offline, i.e., de-energization. With a Transformer with LTC, whenever one phase of the tap changer fails or requires maintenance, the entire "package" is removed from service—all phases are affected. With single-phase Regulators, if one phase goes offline, it can be replaced with another single-phase unit. One spare Regulator can roll through all three phases when maintenance is required; the same spare unit can function



effectively on any of the system's three phases. Full maintenance can be completed without diminishing service anywhere on the system. Spare equipment may be available from emergency reserves, from another substation, or as new-direct from the manufacturer or nearby distributor.

Operation of a single-phase Regulator is essentially the same as for a three-phase device. The main difference is in the separation of the three phases into separate tanks. In separating the active tap-changing mechanisms, several benefits are seen. Each single-phase unit has an independent control to react individually to the voltage variances of the phase. Where phase voltages are unbalanced, e.g., in single-phase loading on residential feeders, single-phase units can respond individually to these independent feeder models. Individual line-drop settings can be used to model each phase.

By separating the phases, each into its own unit, every unit is made smaller and easier to handle. To a utility, this can mean the difference between using material-moving equipment at hand versus having to contract out for special services. Change-outs can be completed in hours, rather than days. Normal service is quickly restored. Nuisance complaints are minimized.

The Engineering function is often called upon to provide a contingency plan to transfer load in the event of product failure or scheduled maintenance. Bypass switching provides easy installation and the ability to remove a regulator without "dropping" the entire feeder or bus. Bypassing and the use of spare regulators allow for a simpler load transfer. When standard products are used, the product manufacturer can assist in devising a voltage regulation plan. This type of plan can be integrated into other utility projects such as load management or SCADA connection at the substation.

Cost comparisons for the two alternatives are shown below.

Table 1. Life Cycle Cost Evaluation

	Regulators	Other Equipment	Initial Cost	Maintenance every 5 years will have 5 charges over 30 years	30 yr. Cost
(1) Transformer & 1Ø Regulators	\$ 95,000	\$2,500	\$97,500	\$10,000 each occurrence	\$147,500
(2) LTC transformer	\$120,000	\$ 0	\$120,000	\$35,000 each occurrence	\$295,000

Other equipment includes additional busywork and bypass switches.

Maintenance costs are based on \$25,000 per LTC repair and a \$10,000 Engineering study for load transfer when a LTC unit is removed, \$10,000 for a regulator change-out and repair.

Based on 7620 phase-to-neutral, 438 ampere rating.

Clearly, Alternative (1), the single-phase Regulator in conjunction with the non-LTC Transformer, is more cost effective. Further, both the Regulator and the Transformer in Alternative (1) will typically be of a more standard design than the unit in Alternative (2). Standardization brings additional time savings and cost savings through shorter order lead times, availability of lower cost spares from the manufacturer, versatility of spares in utility stock, ease of field installation and maintenance, and increased line crew safety levels through consistent operation procedures.

Simplification through standardization. The voltage supply function can be made simpler, after all.

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