April, 2014

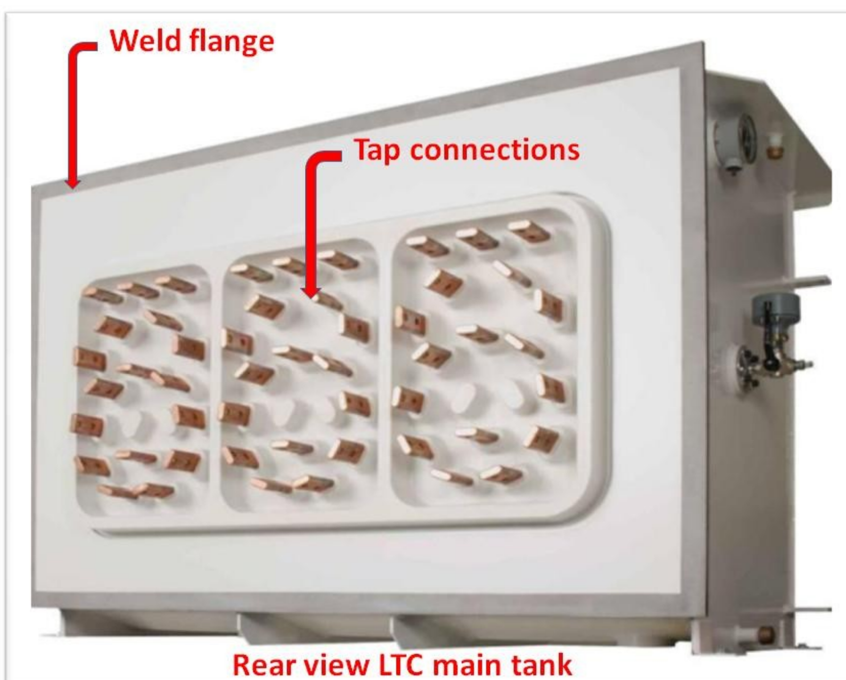
Load Tap Changers

Voltage fluctuations on transmission grids often require transformers to have either short term or long term regulation capability. The easiest way to do this is to add or subtract turns to the transformer windings. Tap changer switches provide an external means to accomplish this voltage adjustment.

Most transformers include a manually operated tap changer switch on the high voltage winding. Manual tap changer adjustments can only be made however, while the transformer is deenergized. On power distribution networks, a large step-down transformer may include an off-load tap changer and an on-load automatic tap changer (LTC). The off load tap changer is set to match the long term system profile on the high voltage network and is rarely changed. The LTC tap changer however, may change positions several times a day, to accommodate varying load conditions, without interrupting the power supply.

The high voltage deenergized tap changer is normally mounted in the main tank of the liquid filled transformer while depending on size, LTCs can be internal to the main tank or contained within a separate, sealed liquid filled compartment with feed though tap connections located on the rear panel (below).

The "external" LTC is welded around a cutout on the front of the transformer tank after which the tap connections are made to a regulator winding that is connected in series with the transformer winding.



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The photo to the right is of a transformer in production, with the liquid filled LTC welded to the front of the transformer's main tank. Located directly below the LTC is the control cabinet which houses the solid state controls.

The key components of the load tap changer include:

Selector Switches

These switches select the physical tap position on the transformer's regulating windings. They do not however, make or break the load current.

Preventative Autotransformers (PA)

The preventive autotransformer serves as a current limiting device when the LTC is sitting on a bridging (odd number) tap position or passing through a bridging (odd number) tap position.

Since the load current must never be interrupted during a tap change, there is an interval where two voltage taps are spanned. The PA (also known as bridging a reactor) is used in the circuit to increase the impedance of the selector circuit and limit the amount of current circulating due to this voltage difference. Under normal load conditions, equal load current flows in both halves of the PA windings and the fluxes balance out with no resultant flux in the core.

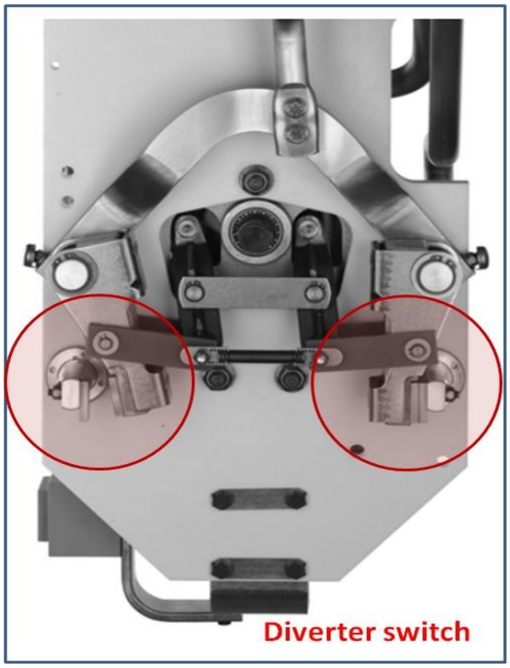
With no flux, there is no inductance and, therefore, no voltage drop due to inductance. There will be however, a very small voltage drop due to resistance. During the tap change, the selector switches are positioned on different taps and a circulating current flows in the reactor circuit. This circulating current creates a flux and the resulting inductive reactance limits the flow of circulating current.

Vacuum Interrupter

This device acts as a circuit breaker that makes and breaks current during the tap changing sequence. With the arcing contacts contained in the vacuum bottle, there is no arc to contaminate the oil.

Diverter Switch

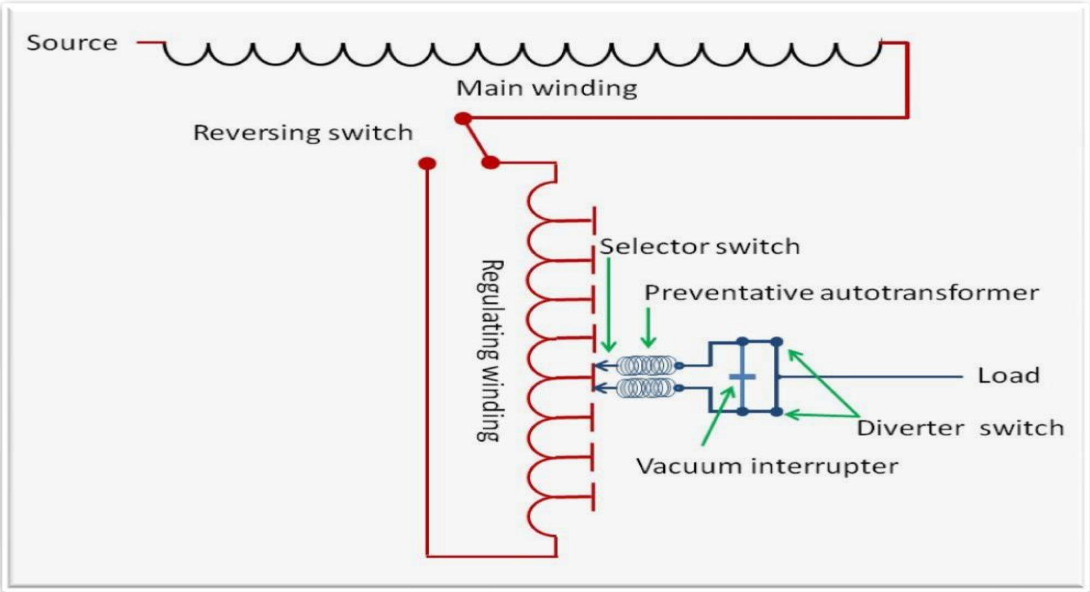
Also known as a bypass switch, this device operates during the tap changing sequence but, at no time makes or breaks load current, though it does make before break each connection.



The picture to the right highlights that the switch is comprised of 2 sets of contacts which are opened or closed by way of signals from the solid state control.

The operating mechanism for the LTC is motor driven. Manual operation is used in the event of motor failure.

The sequence of operation is mechanically linked, or interlocked, to ensure that all contacts always operate in their correct order. Any failure of the operating mechanism can result in severe damage to the transformer and tap changer.



Schematic detailing key components of LTC transformer

PACIFIC CREST TRANSFORMERS

Reversing Switch

A standard 32 step LTC is comprised of 16 each 5/8% raise positions and 16 each 5/8% lower positions. The physical taps are located on a regulating winding within the main transformer tank which is connected in series with the main winding via a reversing switch. Voltage is increased or decreased by movable contacts which use a "stepping " action to move from one connection to the next to add or subtract turns on the regulating winding. The raise or lower mode is dependent on the polarity on the connection through the switch. The eight approximate 1¼% taps on the regulating winding and center tapped preventative autotransformer provide for the individual 5/8% incremental voltage adjustments. The reversing switch enables the windings to double the number of tap positions without doubling the number of tap leads from the tap (regulating) windings.

Definitions

Neutral Position

▪The neutral position is the position where the LTC is neither bucking nor boosting voltage and/or where the tap windings are not in the circuit.

▪This is nominal position.

▪The neutral position is the only position where the reversing switch is not carrying current.

Full Cycle Position

▪A Non-bridging position in an LTC. Both or all moveable contacts of the selector switch are on the same stationary contact and only one tap of the tapped winding.

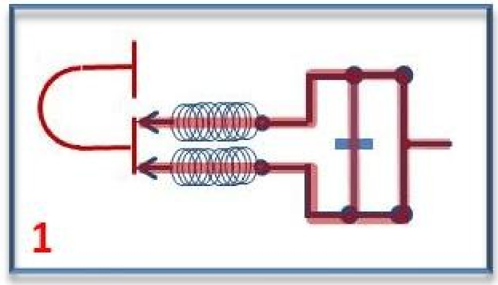
Half Cycle Position

▪A Bridging position in an LTC. The moveable contacts of the selector switch are on separate (different) stationary contacts and two points on the tapped winding. The turns ratio at the bridging tap position is the mean average of the two adjacent non-bridging tap positions, since the preventive autotransformer/reactor provides the center tap.

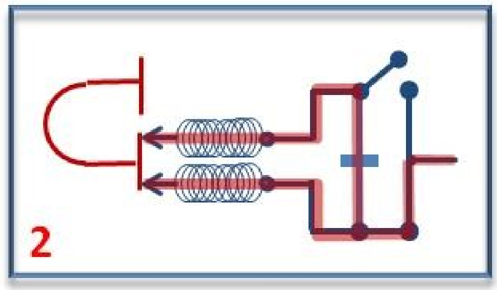
The LTC control circuitry includes means to allow for operator selected setpoints to determine the need for a raise or lower tap change operation in order to maintain the transformer output voltage to within a desired band.

The sequence of events during a physical tap change:

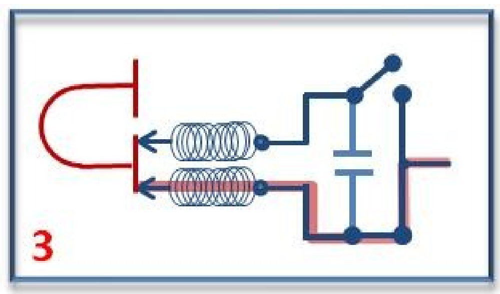
1. Both selector switch contacts located on common tap connection. Vacuum interrupter and diverter switch contacts are in closed position.



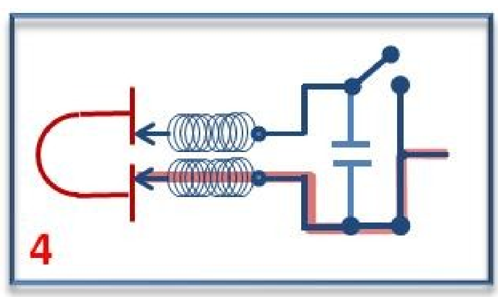
2. Selector switch contacts remain on common tap. Vacuum interrupter remains closed allowing upper diverter switch contacts to open without drawing an arc.



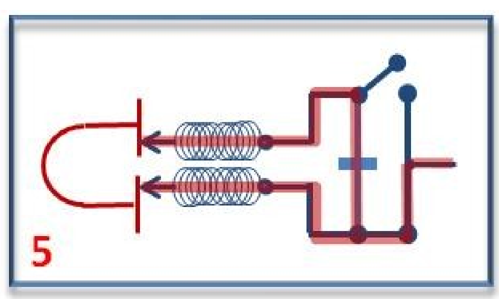
3. Vacuum interrupter opens. Current flow through upper selector switch has been cut.



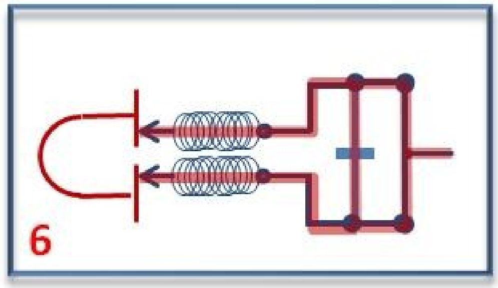
4. With no current flow in upper selector contact, switch is free to move one step up to bridge with next tap connection.



5. Vacuum interrupter closes to establish bridging tap connection.

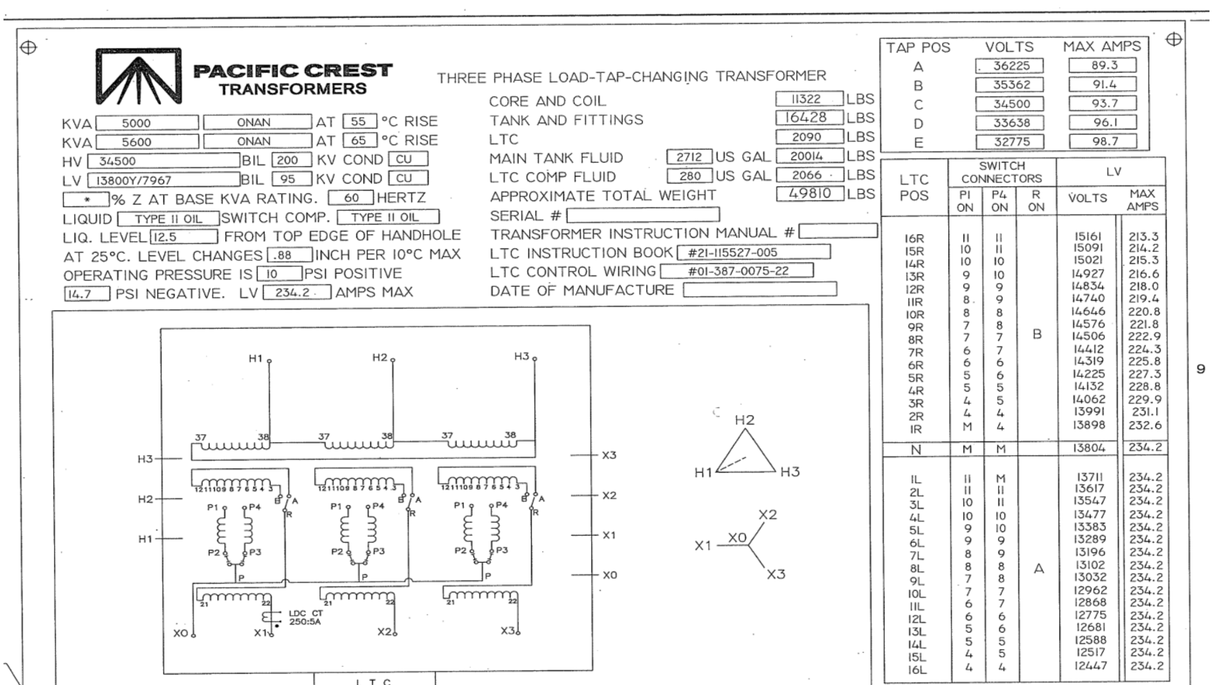


6. Upper diverter switch closes without arc since current flow path has been established through vacuum interrupter. Tap change complete.



IEEE standard C57.131-2012

Description: This standard covers electrical and mechanical performance and test requirements for tap changers installed in voltage regulating power and distribution transformers of all voltage and kVA ratings. It covers load tap changers (LTCs), also known as on-load tap changers (OLTCs), which can change taps while the transformer is energized and carrying load; and it covers de-energized tap changers (DETCs), also known as off-circuit tap changers, which may be operated only while the transformer is not energized. For load tap changers, this standard covers both resistor and reactor types. It also covers certain aspects of the attendant tap changer motor-drive mechanism. It does not cover the tap changer control system (manual or automatic).



PACIFIC CREST TRANSFORMERS

THREE PHASE LOAD-TAP-CHANGING TRANSFORMER

KVA 5000 ONAN AT 55 °C RISE
KVA 5600 ONAN AT 65 °C RISE
HV 34500 BIL 200 KV COND CU
LV 13800Y/7967 BIL 95 KV COND CU
* % Z AT BASE KVA RATING. 60 HERTZ
LIQUID TYPE II OIL SWITCH COMP. TYPE II OIL
LIQ. LEVEL 12.5 FROM TOP EDGE OF HANDHOLE
AT 25°C. LEVEL CHANGES .88 INCH PER 10°C MAX
OPERATING PRESSURE IS 10 PSI POSITIVE
14.7 PSI NEGATIVE. LV 234.2 AMPS MAX

CORE AND COIL 11322 LBS
TANK AND FITTINGS 16428 LBS
LTC 2090 LBS
MAIN TANK FLUID 2712 US GAL 20014 LBS
LTC COMP FLUID 280 US GAL 2066 LBS
APPROXIMATE TOTAL WEIGHT 49810 LBS
SERIAL #
TRANSFORMER INSTRUCTION MANUAL #
LTC INSTRUCTION BOOK #21-115527-005
LTC CONTROL WIRING #01-387-0075-22
DATE OF MANUFACTURE

TAP POS	VOLTS	MAX AMPS
A	36225	89.3
B	35362	91.4
C	34500	93.7
D	33638	96.1
E	32775	98.7

LTC POS	SWITCH CONNECTORS			LV	
	P1 ON	P4 ON	R ON	VOLTS	MAX AMPS
16R	11	11	B	15161	213.3
15R	10	11		15091	214.2
14R	10	10		15021	215.3
13R	9	10		14927	216.6
12R	9	9		14834	218.0
11R	8	9		14740	219.4
10R	8	8		14646	220.8
9R	7	8		14576	221.8
8R	7	7		14506	222.9
7R	6	7		14412	224.3
6R	6	6		14319	225.8
5R	5	6		14225	227.3
4R	5	5		14132	228.8
3R	4	5		14062	229.9
2R	4	4		13991	231.1
1R	M	4		13898	232.6
N	M	M		13804	234.2
1L	11	M	A	13711	234.2
2L	11	11		13617	234.2
3L	10	11		13547	234.2
4L	10	10		13477	234.2
5L	9	10		13383	234.2
6L	9	9		13289	234.2
7L	8	9		13196	234.2
8L	8	8		13102	234.2
9L	7	8		13032	234.2
10L	7	7		12962	234.2
11L	6	7		12868	234.2
12L	6	6		12775	234.2
13L	5	6		12681	234.2
14L	5	5		12588	234.2
15L	4	5		12517	234.2
16L	4	4		12447	234.2

Nameplate drawing of recent production unit