

ECLA**EUROPEAN CLASSIFICATION****H02H**

EMERGENCY PROTECTIVE CIRCUIT ARRANGEMENTS (indicating or signalling undesired working conditions [G01R](#), e.g. [G01R31/00](#), [G08B](#); locating faults along lines [G01R31/08](#); emergency protective devices [H01H](#))

Note

This subclass covers only circuit arrangements for the automatic protection of electric lines or electric machines or apparatus in the event of an undesired change from normal working conditions

H02H1/00**Details of emergency protective circuit arrangements**

- H02H1/00C . [N: concerning the detecting means (in general [G01R](#) or other subclasses of [G01](#); reed switches [H01H71/24E](#))]
- H02H1/00C2 . . [N: Using arc detectors]
- H02H1/00C2B . . . [N: sensing non electrical parameters, e.g. by optical, pneumatic, thermal or sonic sensors] [N0004]
- H02H1/00C3 . . [N: Fault detection by injection of an auxiliary voltage (same for detection of earth fault currents [H02H3/17](#); for monitoring earth connection [H02H5/10B](#))]
- H02H1/00D . [N: concerning the connection of the detecting means, e.g. for reducing their number]
- H02H1/00D2 . . [N: Commutating the detecting means in dependance of the fault, e.g. for reducing their number]
- H02H1/00D3 . . [N: Means for storing the measured quantities during a predetermined time]
- H02H1/00E . [N: concerning transmission of signals (transmission of measured quantities or switching orders; sectionalised protection involving signal transmission between at least two stations [H02H7/26B](#); comparison of the voltage or current values at two spaced portions of a single system [H02H3/28](#); transferring the output of a sensing member to another variable [G01D5/00](#); electrical measuring arrangements using modulation of electromagnetic waves, e.g. light beams [G01R15/24](#), [G01R15/26](#))]
- H02H1/00E2 . . [N: by means of light or heat rays]
- H02H1/00E4 . . [N: by superposition on the watched current]
- H02H1/00E5 . . [N: by means of pilot wires or a telephone network; watching of these wires]
- H02H1/00F . [N: concerning the data processing means, e.g. expert systems, neural networks] [N9503]
- H02H1/04 . Arrangements for preventing response to transient abnormal conditions, e.g. to lightning [N: or to short duration over voltage or oscillations; Damping the influence of dc component by short circuits in ac networks]
- H02H1/04B . . [N: to inrush currents ([H02H1/04C](#) takes precedence; differential protection of transformers [H02H7/045](#))]
- H02H1/04C . . [N: upon detecting saturation of current transformers (for differential protection [H02H3/28B](#))]
- H02H1/06 . Arrangements for supplying operative power [N: (power supply arrangements in general [G05F](#), [H02M](#))]

- H02H1/06B . . [N: primary power being supplied by fault current]
- H02H1/06B2 . . . [N: and comprising a shunt regulator]

- H02H3/00** **Emergency protective circuit arrangements for automatic disconnection directly responsive to an undesired change from normal electric working condition with or without subsequent reconnection** (specially adapted for specific types of electric machines or apparatus or for sectionalised protection of cable of line systems [H02H7/00](#); systems for change-over to standby supply [H02J9/00](#)) [N: integrated protection (for motors [H02H7/08E](#))]

- H02H3/00B . [N: responsive to reversal of power transmission direction (reversal of direct current [H02H3/18](#))]

- H02H3/00C . [N: Calibration or setting of parameters]

- H02H3/02 . Details
- H02H3/02B . . [N: concerning the disconnection itself, e.g. at a particular instant, particularly at zero value of current, disconnection in a predetermined order (disconnection at zero value in general [H03K 17/18](#))]

- H02H3/02B2 . . . [N: by short-circuiting]
- H02H3/02C . . [N: Disconnection after limiting, e.g. when limiting is not sufficient or for facilitating disconnection]

- H02H3/027 . . with automatic disconnection after a predetermined time ([H02H3/033](#), [H02H3/06](#) take precedence; [N: timing in overcurrent protection circuits [H02H3/093](#); in undervoltage protection circuits [H02H3/247](#); staggered disconnection [H02H7/30](#)])

- H02H3/033 . . with several disconnections in a preferential order, [N: e.g. following priority of the users, load repartition] ([H02H3/06](#) takes precedence)

- H02H3/04 . . with warning or supervision in addition to disconnection, e.g. for indicating that protective apparatus has functioned [N: (watching of pilot wires [H02H1/00E5](#); protection of protective arrangements [H02H7/00K](#); indication of the state of electronic switches [H03K17/18](#))]

- H02H3/04B . . . [N: combined with means for locating the fault (locating faults in cables [G01R31/08](#))]

- H02H3/04C . . . [N: Checking correct functioning of protective arrangements, e.g. by simulating a fault (for differential current circuit breakers [H02H3/33E2](#))]

- H02H3/04D . . . [N: Signalling the blowing of a fuse (detecting non functioning of a lamp [H05B37/03](#))]

- H02H3/04E . . . [N: Checking overvoltage diverters]

- H02H3/05 . . with means for increasing reliability, e.g. redundancy arrangements [N: (for logic circuits [H03K19/003](#))]

- H02H3/06 . . with automatic reconnection

- H02H3/06B . . . [N: Details concerning the co-operation of many similar arrangements, e.g. in a network (sectionalised protection [H02H7/26](#))]

- H02H3/06C . . . [N: Reconnection being a consequence of eliminating the fault which caused disconnection]

- H02H3/07 . . . and with permanent disconnection after a predetermined number of reconnection cycles

- H02H3/08 . responsive to excess current (responsive to abnormal temperature caused by excess current [H02H5/04](#))

- H02H3/08B . . [N: and depending on the direction]
- H02H3/08D . . [N: for three-phase systems]
- H02H3/08T . . [N: making use of a thermal sensor, e.g. thermistor, heated by the excess current (also responsive to the temperature of the protected device [H02H5/04B](#), thermal images [H02H6/00](#))]
- H02H3/087 . . for dc applications
- H02H3/093 . . with timing means [N: (in general [H02H3/027](#); thermal delay [H02H3/08T](#); timing means for undervoltage protection [H02H3/247](#))]
- H02H3/093B . . . [N: the timing being determined by numerical means]
- H02H3/10 . . additionally responsive to some other abnormal electrical conditions
- H02H3/10B . . . [N: responsive to excess current and fault current to earth]
- H02H3/12 . responsive to underload or no-load [N: (for motors [H02H7/08F](#))]
- H02H3/13 . . for multiphase applications, e.g. phase interruption
- H02H3/14 . responsive to occurrence of voltage on parts normally at earth potential [N: (monitoring earth connection [H02H5/10B](#))]
- H02H3/16 . responsive to fault current to earth, frame or mass (with balanced or differential arrangement [H02H3/26](#); [N: monitoring earth connection [H02H5/10B](#)])
- H02H3/16D . . [N: for ac systems]
- H02H3/16D2 . . . [N: for three-phase systems]
- H02H3/16F . . [N: combined with other earth-fault protective arrangements]
- H02H3/17 . . by means of an auxiliary voltage injected into the installation to be protected [N: (using summation current transformers [H02H3/33](#))]
- H02H3/18 . responsive to reversal of direct current
- H02H3/20 . responsive to excess voltage
- H02H3/20B . . [N: for dc systems]
- H02H3/20C . . [N: using a spark-gap as detector]
- H02H3/20D . . [N: also responsive to under-voltage (window comparators for indication [G01R19/165](#))]
- H02H3/22 . . of short duration, e.g. lightning
- H02H3/24 . responsive to undervoltage or no-voltage [N: ([H02H3/20D](#) takes precedence)]
- H02H3/24B . . [N: for DC systems] [N0505]
- H02H3/247 . . having timing means
- H02H3/253 . . for multiphase applications, e.g. phase interruption
- H02H3/26 . responsive to difference between voltages or between currents; responsive to phase angle between voltages or between currents
- H02H3/26B . . [N: responsive to phase angle between voltages or between currents]
- H02H3/28 . . involving comparison of the voltage or current values at two spaced portions of a single system, e.g. at opposite ends of one line, at input and output of apparatus [N: (for transformers [H02H7/045](#))]
- H02H3/28B . . . [N: and taking into account saturation of current transformers]
- H02H3/28C . . . [N: involving comparison of similar homopolar quantities]

H02H3/30	. . . using pilot wires or other signalling channel
H02H3/30B	. . . . [N: involving phase comparison]
H02H3/30C	. . . . [N: involving current comparison]
H02H3/30D	. . . . [N: involving comparison of quantities derived from a plurality of phases, e.g. homopolar quantities; using mixing transformers]
H02H3/32	. . involving comparison of the voltage or current values at corresponding points in different conductors of a single system, e.g. of currents in go and return conductors
H02H3/32C	. . . [N: involving voltage comparison (H02H3/347 takes precedence)]
H02H3/33	. . . using summation current transformers (H02H3/347 takes precedence)
H02H3/33B	. . . . [N: responsive to earthing of the neutral conductor (H02H3/33L takes precedence)]
H02H3/33D	. . . . [N: with means responsive to dc component in the fault current]
H02H3/33E	. . . . [N: with means to produce an artificial unbalance for other protection or monitoring reasons or remote control (H02H3/33L takes precedence)]
H02H3/33E2	. . . . . [N: the main function being self testing of the device]
H02H3/33F	. . . . [N: avoiding disconnection due to reactive fault currents]
H02H3/33L	. . . . [N: also responsive to wiring error, e.g. loss of neutral, break]
H02H3/34	. . . of a three-phase system
H02H3/34D	. . . . [N: using phase sequence analysers]
H02H3/347	. . . . using summation current transformers
H02H3/353	. . . . involving comparison of phase voltages
H02H3/36	. . involving comparison of the voltage or current values at corresponding points of different systems, e.g. of parallel feeder systems
H02H3/36B	. . . [N: one of the systems simulating the other system]
H02H3/38	. responsive to both voltage and current; responsive to phase angle between voltage and current
H02H3/38B	. . [N: involving phase comparison between current and voltage or between values derived from current and voltage]
H02H3/38C	. . [N: using at least one homopolar quantity]
H02H3/38D	. . [N: using phase-sequence analysing arrangements]
H02H3/40	. responsive to ratio of voltage and current
H02H3/40B	. . [N: using homopolar quantities]
H02H3/40C	. . [N: using phase sequence analysing arrangements]
H02H3/40D	. . [N: using induction relays]
H02H3/42	. responsive to product of voltage and current
H02H3/42B	. . [N: using homopolar quantities]
H02H3/42C	. . [N: using phase sequence analysing arrangements]
H02H3/42D	. . [N: using induction relays]
H02H3/44	. responsive to the rate of change of electrical quantities
H02H3/44B	. . [N: of DC quantities]
H02H3/46	. responsive to frequency deviations

H02H3/48	<ul style="list-style-type: none"> responsive to loss of synchronism
H02H3/50	<ul style="list-style-type: none"> responsive to the appearance of abnormal wave forms, e.g. ac in dc installations
H02H3/52	<ul style="list-style-type: none"> <ul style="list-style-type: none"> responsive to the appearance of harmonics
H02H5/00	Emergency protective circuit arrangements for automatic disconnection directly responsive to an undesired change from normal non-electric working conditions with or without subsequent reconnection (using simulators of the apparatus being protected H02H6/00; specially adapted for specific types of electric machines or apparatus or for sectionalised protection of cable or line systems H02H7/00)
H02H5/00B	<ul style="list-style-type: none"> [N: responsive to ionising radiation; Nuclear-radiation circumvention circuits (radiation detectors G01T; nuclear-explosion detection G21J5/00)]
H02H5/04	<ul style="list-style-type: none"> responsive to abnormal temperature [N: specially adapted for electric machines H02H7/085C]
H02H5/04B	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: additionally responsive to excess current (H02H5/04T2 takes precedence)]
H02H5/04D	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: using temperature dependent resistors]
H02H5/04D2	<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: the temperature dependent resistor being disposed parallel to a heating wire, e.g. in a heating blanket]
H02H5/04F	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: using a semiconductor device to sense the temperature]
H02H5/04H	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: using a thermal radiation sensor]
H02H5/04K	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: using a thermocouple]
H02H5/04T	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: using a temperature responsive switch]
H02H5/04T2	<ul style="list-style-type: none"> <ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: additionally responsive to excess current due to heating of the switch]
H02H5/06	<ul style="list-style-type: none"> <ul style="list-style-type: none"> in oil-filled electric apparatus
H02H5/08	<ul style="list-style-type: none"> responsive to abnormal fluid pressure, liquid level or liquid displacement, e.g. Buchholz relays
H02H5/08B	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: responsive to the entry or leakage of a liquid into an electrical appliance (moisture alarm G08B21/00B1)]
H02H5/08C	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: of cooling or lubricating fluids]
H02H5/10	<ul style="list-style-type: none"> responsive to mechanical injury, e.g. rupture of line, breakage of earth connection
H02H5/10B	<ul style="list-style-type: none"> <ul style="list-style-type: none"> [N: responsive to deterioration or interruption of earth connection (for preventing switching-on H02H11/00B)]
H02H5/12	<ul style="list-style-type: none"> responsive to undesired approach to, or touching of, live parts by living beings
H02H6/00	Emergency protective circuit arrangements responsive to undesired changes from normal non-electric working conditions using simulators of the apparatus being protected, e.g. using thermal images
H02H6/00B	<ul style="list-style-type: none"> [N: using digital thermal images]
H02H7/00	Emergency protective circuit arrangements specially adapted for specific types of electric machines or apparatus or for sectionalised protection of cable or line systems, and effecting automatic switching in the event of an undesired change from normal working conditions (structural association of protective devices with specific machines or apparatus and their protection without automatic

connection, see the relevant subclass for the machine or apparatus)

- H02H7/00C . [N: for supra-conducting apparatus, e.g. coils, lines, machines]
- H02H7/00D . [N: for electrostatic apparatus]
- H02H7/00F . [N: for remote controlled apparatus; for lines connecting such apparatus]
- H02H7/00H . [N: for non-insulated low-voltage distribution systems, e.g. low-voltage halogen-lamp system]
- H02H7/00K . [N: for protective arrangements according to this subclass ([H02H9/04C](#), [H02H9/04D](#) take precedence; protection of spark-gaps [H02H7/24](#))]
- H02H7/04 . for transformers
- H02H7/04B . . [N: for current transformers]
- H02H7/045 . . Differential protection of transformers
- H02H7/045B . . . [N: taking into account saturation of current transformers]
- H02H7/05 . . for capacitive voltage transformers, e.g. against resonant conditions
- H02H7/055 . . for tapped transformers or tap-changing means thereof
- H02H7/06 . for dynamo-electric generators; for synchronous capacitors
- H02H7/06B . . [N: for parallel connected generators]
- H02H7/06C . . [N: against excitation faults]
- H02H7/06D . . [N: on occurrence of a load dump (control on sudden change of load [H02P9/10](#); safety devices for generators driven at varying speed [H02J7/14H](#))]
- H02H7/08 . for dynamo-electric motors
- H02H7/08B . . [N: for synchronous motors]
- H02H7/08C . . [N: for dc motors ([H02H7/08H](#) takes precedence)]
- H02H7/08D . . [N: concerning the starting sequence, e.g. limiting the number of starts per time unit, monitoring speed during starting]
- H02H7/08E . . [N: Integrated protection, motor control centres]
- H02H7/08F . . [N: responsive to underload or no-load, e.g. pump-off control circuits for pump motors]
- H02H7/08H . . [N: for electric motors with control arrangements]
- H02H7/08H2 . . . [N: with H-bridge circuit]
- H02H7/08H4 . . . [N: Fail safe control, e.g. by comparing control signal and controlled current, isolating motor on commutation error]
- H02H7/085 . . against excessive load [N: ([H02H6/00](#) takes precedence)]
- H02H7/085B . . . [N: for motors actuating a movable member between two end positions, e.g. detecting an end position or obstruction by overload signal]
- H02H7/085C . . . [N: directly responsive to abnormal temperature by using a temperature sensor (in a control circuit [H02H7/08H](#))]
- H02H7/085D . . . [N: specially adapted for motors rotating in both directions ([H02H7/085B](#) takes precedence)]
- H02H7/085E . . . [N: responsive to rate of change of current, couple or speed, e.g. anti-kickback]

- protection ([H02H7/085B](#) takes precedence)]
- [H02H7/085F](#) . . . [N: avoiding response to transient overloads, e.g. during starting]
- [H02H7/085G](#) . . . [N: characterised by the protection measure taken]
- [H02H7/085G2](#) [N: by lowering the mechanical load of the motor]
- [H02H7/085G4](#) [N: by reversing, cycling or reducing the power supply to the motor]
- [H02H7/085G6](#) [N: avoiding restarting after fault condition has disappeared]
- [H02H7/09](#) . . against over-voltage; against reduction of voltage; against phase interruption
- [H02H7/093](#) . . against increase beyond, or decrease below, a predetermined level of rotational speed ([centrifugal switches](#) [H01H35/10](#))
- [H02H7/097](#) . . against wrong direction of rotation
- [H02H7/10](#) . for converters; for rectifiers [N: (forming part of the control circuit of the converter, see the relevant group in [H02M](#))]
- [H02H7/10B](#) . . [N: for rotating converters]
- [H02H7/10C](#) . . [N: for dynamic converters]
- [H02H7/12](#) . . for static converters or rectifiers [N: (for discharge lamp power supplies using static converters [H05B41/285C](#), [H05B41/292C](#), [H05B41/298C](#))] [C9906]
- [H02H7/12A](#) . . . [N: Circuits independent of the type of conversion]
- [H02H7/12A2](#) [N: specially adapted to conversion cells composed of a plurality of parallel or serial connected elements]
- [H02H7/12B](#) . . . [N: for converters using only discharge tubes]
- [H02H7/12C](#) . . . [N: for DC-DC converters]
- [H02H7/12D](#) . . . [N: for AC-AC converters]
- [H02H7/122](#) . . . for inverters, i.e. dc/ac converters
- [H02H7/122B](#) [N: responsive to abnormalities in the input circuit, e.g. transients in the DC input]
- [H02H7/122C](#) [N: responsive to internal faults, e.g. shoot-through ([avoiding shoot-through](#) [H02M1/00P2](#))]
- [H02H7/122D](#) [N: responsive to abnormalities in the output circuit, e.g. short circuit]
- [H02H7/125](#) . . . for rectifiers
- [H02H7/125B](#) [N: responsive to overvoltage in input or output, e.g. by load dump]
- [H02H7/125C](#) [N: responsive to internal faults, e.g. by monitoring ripple in output voltage]
- [H02H7/125D](#) [N: responsive to short circuit or wrong polarity in output circuit]
- [H02H7/127](#) having auxiliary control electrode to which blocking control voltages or currents are applied in case of emergency
- [H02H7/16](#) . for capacitors ([for synchronous capacitors](#) [H02H7/06](#))
- [H02H7/18](#) . for batteries; for accumulators
- [H02H7/20](#) . for electronic equipment ([for converters](#) [H02H7/10](#); [for electric measuring instruments](#) [G01R1/36](#); [for dc voltage or current semiconductor regulators](#) [G05F1/569](#); [for amplifiers](#) [H03F1/52](#); [for electronic switching circuits](#) [H03K17/08](#))
- [H02H7/20B](#) . . [N: for controlled semi-conductors which are not included in a specific circuit arrangement]
- [H02H7/22](#) . for distribution gear, e.g. bus-bar systems; for switching devices [N: ([detecting mechanical or electrical defects in gas-insulated switchgears](#) [H02B13/065](#))]

- H02H7/22B . . [N: for switches]
- H02H7/22B2 . . . [N: Anti-pump circuits]
- H02H7/22C . . [N: for wires or cables, e.g. heating wires]
- H02H7/22D . . [N: for covered wires or cables]

- H02H7/24 . for spark-gap arresters

- H02H7/26 . Sectionalised protection of cable or line systems, e.g. for disconnecting a section on which a short-circuit, earth fault, or arc discharge has occurred ([locating faults in cables G01R31/08](#))

- H02H7/26B . . [N: involving signal transmission between at least two stations ([transmission of signals in general H02H1/00E](#))]
- H02H7/26B2 . . . [N: involving transmissions of switching or blocking orders]
- H02H7/26B3 . . . [N: involving transmissions of measured values ([comparison of currents or voltages using pilot wires H02H3/30](#))]
- H02H7/26C . . [N: making use of travelling wave theory]
- H02H7/26D . . [N: involving switching on a spare supply ([in general H02J9/00](#))]
- H02H7/26F . . [N: for parallel lines and wires]
- H02H7/26G . . [N: for dc systems]
- H02H7/28 . . for meshed systems
- H02H7/30 . . staggered disconnection

- H02H9/00** **Emergency protective circuit arrangements for limiting excess current or voltage without disconnection (structural association of protective devices with specific machines or apparatus, see the relevant subclass for the machine or apparatus)**

- H02H9/00C . [N: limiting speed of change of electric quantities, e.g. soft switching on or off ([progressive control of electronic switches for eliminating interferences H03K17/16](#))] [C9412]
- H02H9/00C2 . . [N: limiting inrush current on switching on of inductive loads subjected to remanence, e.g. transformers]
- H02H9/00C4 . . [N: in connection with live-insertion of plug-in units ([involving communication with a central processing unit G06F13/40](#))]

- H02H9/00D . [N: avoiding undesired transient conditions]
- H02H9/00D2 . . [N: avoiding or damping oscillations, e.g. ferroresonance or travelling waves]

- H02H9/00E . [N: Intrinsically safe circuits]

- H02H9/02 . responsive to excess current [N: ([current limitation for voltage regulators G05F1/573; disconnection after limiting H02H3/02C](#))]
- H02H9/02B . . [N: Current limitation using saturable reactors ([H02H9/02C](#) takes precedence)]
- H02H9/02C . . [N: Current limitation using supraconducting elements]
- H02H9/02D . . [N: Current limitation using field effect transistors]
- H02H9/02E . . [N: Current limitation using PTC resistors, i.e. resistors with a large positive temperature coefficient]
- H02H9/02F . . [N: Current limitation by detuning a series resonant circuit ([H02H9/02B, H02H9/02C](#) take precedence)]

- H02H9/04 . responsive to excess voltage (lightning arrestors [H01C7/12](#), [H01C8/04](#), [H01G9/18](#), [H01T](#))
- H02H9/04B . . [N: using a short-circuiting device]
- H02H9/04C . . [N: comprising means to limit the absorbed power or indicate damaged over-voltage protection device]
- H02H9/04D . . [N: Protection of over-voltage protection device by short-circuiting]
- H02H9/04E . . [N: Physical layout, materials not provided for elsewhere (varistors [H01C7/12](#); Ovshinsky devices [H01L45/00](#); spark-gaps [H01T](#))]
- H02H9/04F . . [N: adapted to a particular application and not provided for elsewhere]
- H02H9/04F2 . . . [N: responsive to excess voltage appearing at terminals of integrated circuits (protection by specific structural integration design [H01L27/02B4](#))] [C9704]
- H02H9/04F4 . . . [N: Free-wheeling circuits]
- H02H9/04G . . [N: Anti-latching or quenching devices, i.e. bringing the protection device back to its normal state after a protection action]
- H02H9/04H . . [N: Circuit arrangements for limiting the number of protection devices]
- H02H9/06 . . using spark-gap arresters
- H02H9/08 . limitation or suppression of earth fault currents, e.g. Petersen coil
- H02H11/00** **Emergency protective circuit arrangements for preventing the switching-on in case an undesired electric working condition might result**
- H02H11/00B . [N: in case of incorrect or interrupted earth connection (disconnection by breaking of earth connection [H02H5/10B](#))]
- H02H11/00C . [N: in case of inverted polarity or connection; with switching for obtaining correct connection]
- H02H11/00C2 . . [N: using a field effect transistor as protecting element in one of the supply lines] [N0002]
- H02H11/00D . [N: in case of incorrect phase sequence; with switching for obtaining correct phase sequence (protection of motors against wrong direction of rotation [H02H7/097](#))]
- H02H11/00E . [N: in case of too low isolation resistance, too high load, short-circuit; earth fault]
- H02H11/00F . [N: in case of too high or too low voltage]
- H02H11/00F2 . . [N: involving automatic switching for adapting the protected apparatus to the supply voltage]
- H02H11/00S . [N: preventing unsafe switching operations in substations (Schaltfehlerschutz)]