A New Hybrid Multi-Level Voltage-Source Converter with DC Fault Blocking Capability

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Abstract— This paper clarifies the working standards, supported by simulation results, of another converter topology proposed for HVDC application, called the Alternate Arm Converter (AAC). It is hybrid between the multilevel converter, as a result of the presence of H-bridge cells, and the 2-level converter, as chief switches in each arm. This converter can create a multi-level AC voltage and, since its heaps of cells comprise of H-connect cells rather than halfbridge cells, they can produce higher AC voltage than the DC terminal voltage. This permits the AAC to work at an ideal point, called the "sweet spot", where the AC and DC energy streams equivalent. The chief switches in the AAC are answerable for rotating the conduction time of each arm, prompting a critical decrease in the quantity of cells in the stacks. Moreover, the AAC can keep control of the current in the stage reactor even if there should arise an occurrence of a DC-side deficiency and backing the AC lattice, through a STATCOM mode. Recreation results and misfortune counts are introduced in this paper to help the asserted highlights of the AAC.

Keywords: DC-AC converter, HVDC application, Alternate Arm Converter (AAC)

I. INTRODUCTION

The development of VSC-HVDC technology highly relies on the performance of the dc-ac converters. Due to the high modularity and low power losses, modular multilevel converter (MMC) has replaced two-level converter and become the most popular dc-ac converter for high voltage applications. However, the conventional MMC has two drawbacks. First, a large quantity of capacitors are involved which makes the footprint less attractive. This is especially important for offshore windfarm applications which are typically very sensitive to the dimension issue. Second, the normally adopted half bridge (HB) type is not capable of dealing with dc faults. The whole system must be tripped under such conditions because the ac system continuously feeds fault current through the diodes. This results in that HB MMC cannot be the solution for overhead line system where temporary dc faults may happen. Although the full bridge (FB) structure can interrupt the dc fault current, the cost of semiconductors is recognized as double that of HB scheme and its power losses have been proven to be up to 70% higher than HB scheme, which is unacceptable.

II. DC-AC CONVERTERS

DC to AC converters is mainly designed for changing a DC power supply to an AC power supply. Here, DC power supply is comparatively stable as well as positive voltage source whereas AC oscillates approximately a 0V base stage, typically in a sinusoidal or square or mode. The common inverter technology used in electronics is to convert a voltage source from a battery into an AC signal. Generally, they operate with 12 volts and commonly used in applications like automotive, lead-acid technology, photovoltaic cells, etc. A transformer coil system & a switch is the simple circuit used for an inverter. A typical transformer can be connected toward the DC signal's input through a switch to oscillate back quickly. Due to the current flow in bi-directional in the primary coil of the transformer, an alternating current signal is an output throughout the secondary coils.

Expanding consideration is being paid to HVDC transmission frameworks, particularly on the grounds that a large portion of the new plans are planned to associate distant inexhaustible sources to the network and the best method to do it is to send the created power utilizing HVDC rather than HVAC. For seaward HVDC applications, Voltage Source Converters (VSC) are more reasonable than Current Source Converter (CSC), because of their dark beginning capacity and capacity to work in frail AC frameworks, like an organization of wind turbine generators. Nonetheless, contrasted with CSC, their force appraisals are restricted and their effectiveness to some degree less fortunate albeit late advancements in semi-conductor gadgets are shutting the hole in the two cases to such an extent that VSCs are getting financially feasible as mechanical arrangements in enormous HVDC plans; some of them to be authorized in the a few years.

In the VSC arrangement, the battery bank can be associated straightforwardly to the dc/ac stage capacitor or associated through the dc/dc stage. The hindrance of this geography is the chance of working just as a buck converter. Thusly, the yield voltage should be lower than the dc voltage. Also, the upper and lower switches of each stage leg can't be enacted all the while. Hence, a dead time between the opening and shutting of the switches should be executed, which misshapes the yield waveform.

Despite the benefits brought by this new age of converter, there are a few angles that can in any case be improved. The evasion of the AC channel implies that the phones are presently perhaps the bulkiest segment of the converter station and cell design requires an actually huge capacitor notwithstanding the arrangement of IGBTs. Half-connect cells are ordinarily utilized in inclination to H-connect cells) to lessen the quantity of gadgets in conduction whenever and subsequently diminish the conduction power misfortune. Regardless of whether this decision is advocated by the enormous expense related with the force misfortunes, it likewise implies that the converter is powerless against a DC-side shortcoming along these lines to a 2-level converter though a Hbridge rendition would not be. The powerlessness of half-connect cells to deliver a negative voltage brings about the conduction of the counter equal diodes associated with the IGBTs, subsequently making a wild current way if

there should be an occurrence of a breakdown of the DC transport voltage.

III. SCOPE AND OBJECTIVE

To enhance the MMC circuit topology, a dedicated control strategy is developed for the open-circuit liability sensing.
To record the sub module voltage level and register the better flow of Power control.

IV. LITERATURE SURVEY

Lucas S. Xavier et.al (2019), describes the development of battery energy stockpiling framework (BESS) in the electrical framework. In the situation of high entrance level of environmentally friendly power in the conveyed age, BESS assumes a vital part in the push to consolidate a practical force supply with a dependable dispatched load. A few force converter geographies can be utilized to associate BESS to the framework. There is no characterized and normalized arrangement, particularly for medium voltage applications. This work expects to complete a writing survey on the fundamental converter geographies utilized in BESS and feature the principle benefits and inconveniences of every one. The geographies utilized for every change stage are introduced and their mixes are dissected. Likewise, the various administrations that BESS can complete when associated with the dispersion framework are broke down to exhibit every one of the principle commitments to the electrical frameworks. At long last, a contextual analysis is performed to think about and break down the converter geographies for BESS, considering a few viewpoints like effectiveness, power quality and number of segments.

Michael M. C. Merlin et.al (2014), presents the working standards, upheld by reproduction results, of another converter geography proposed for HVDC application, called the Alternate Arm Converter (AAC). It is crossover between the secluded staggered converter, in light of the presence of H-connect cells, and the 2-level converter, as chief switches in each arm. This converter can create a staggered AC voltage and, since its heaps of cells comprise of H-connect cells rather than halfbridge cells, they can produce higher AC voltage than the DC terminal voltage. This permits the AAC to work at an ideal point, called the "sweet spot", where the AC and DC energy streams equivalent. The chief switches in the AAC are answerable for rotating the conduction time of each arm, prompting a huge decrease in the quantity of cells in the stacks. Besides, the AAC can keep control of the current in the stage reactor even in the event of a DC-side deficiency and backing the AC matrix, through a STATCOM mode. Reproduction results and misfortune counts are introduced in this paper to help the asserted highlights of the AAC.

G.P. Adam et.al (2016) presents an exhaustive survey of high-power dc-dc converters for high-voltage direct current (HVDC) transmission frameworks, with accentuation on the most encouraging geographies from set up and arising dc-dc converters. Also, it features the vital difficulties of dc-dc converter versatility to HVDC applications, and limits the ideal highlights for high-voltage dc-dc converters, thinking about both gadget and framework points of view. Qualities and impediments of every dc-dc converter considered in this examination are clarified in detail and upheld by time-area recreations. It is tracked down that the front-to-front semi two-level worked measured staggered converter, change arm secluded converter and controlled progress connect converter offer the best answers for high-voltage dc-dc converters that don't bargain galvanic detachment and counteraction of dc shortcoming proliferation inside the dc organization. Aside from dc deficiency reaction, the MMC dc auto transformer and the transformerless half and half fell two-level converter offer the most proficient answers for tapping and dc voltage coordinating of multi-terminal HVDC organizations.

Mike Barnes et.al (2011) states an outline of the cutting edge in voltage source HVDC right now. HVDC is presented from its underlying chronicled improvement, the acquaintance of line-commutated HVDC with present voltagesource HVDC plans. Converter control and coordination is examined as are multi-terminal control and the requirement for DC breakers to encourage such multi-terminal frameworks. Advancements in DC breakers are checked on. The significance of unwavering quality, especially of the link, is featured and the issues encompassing link demonstrating are momentarily examined. A rundown of VSC-HVDC establishments, both in progress and arranged, is given.

Jyoti M. Kharade et.al (2012) describes a survey of the development in the field of converters for HVDC applications. The diverse converter geographies beginning from Current Source Converter (CSC) or Line Commutated Converter (LCC) up to ongoing progressed or improved Alternate arm Modular Multilevel Converter (AAMMC) with their benefits and downsides have inspected. The Modular Multilevel Converter (MMC) and Alternate Arm Modular Multilevel Converter (AAMMC) geographies are given their highlights like crossover mix with diminished number of gadgets, less misfortunes, DC issue obstructing ability, and so forth which are best and anticipated highlights for HVDC applications.

V. PROPOSED SYSTEM

This paper presents a complete survey of high-power dc-dc converters for high-voltage direct current (HVDC) transmission frameworks, with accentuation on the most encouraging geographies from set up and arising dc-dc converters. Furthermore, it features the vital difficulties of dc-dc converter versatility to HVDC applications, and limits the ideal highlights for high-voltage dc-dc converters, thinking about both gadget and framework viewpoints. Properties and constraints of every dc-dc converter considered in this investigation are clarified in detail and upheld by time-area recreations. It is tracked down that the front-to-front semi two-level worked particular staggered converter, change arm measured converter and controlled progress connect converter offer the best answers for high-voltage dc-dc converters that don't bargain galvanic disengagement and anticipation of dc shortcoming proliferation inside the dc organization.

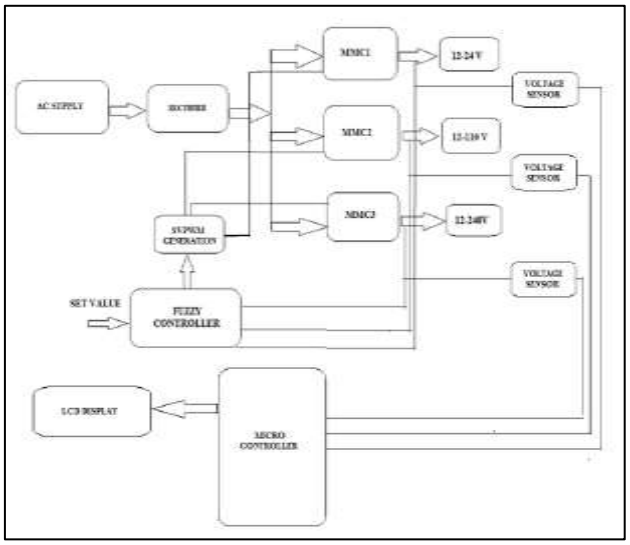


Fig. 1: block diagram

Aside from dc flaw reaction, the MMC dc auto transformer and the transformer less cross breed fell two-level converter offer the most productive answers for tapping and dc voltage coordinating of multi-terminal HVDC organizations.

VI. COMPONENT USED:

A. *Pic Microcontroller*

The microcontrollers played a revolutionary role in embedded industry after the invention of Intel 8051. The steady and progressive research in this field gave the industry more efficient, high performance and low power consumption microcontrollers.

B. *Ports*

1) *I/O Ports*

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin. Additional Information on I/O ports may be found in the IC micro Mid-Range Reference Manual.

C. *Power Supply:*

The input supply i.e., 230V, 50 Hz AC is applied across the essential of a stage down transformer (typically a 12-0-12, i.e., the yield is either 12V or 24V; a transformer is an electromechanical static gadget, which changes one voltage to another without changing its recurrence). The yield is taken across the optional curl and is applied to a rectifier segment.

D. *Resistors:*

A resistor is a passive two-terminal electrical component that implements electrical resistance as a circuit element.

E. *Proteus*

Proteus is a best simulation software for various designs with microcontroller. It is mainly popular because of availability of almost all microcontrollers in it. So it is a handy tool to test programs and embedded designs for electronics hobbyist. You can simulate your programming of microcontroller in Proteus Simulation Software. After simulating your circuit in Proteus Software you can directly make PCB design.

F. *Fault Indicator*

As separated in, the current ways will be affected by the open-circuit issue of the force trading devices, by then the yield of the voltage sensor could be used to complete the speedy defect finding of the MMC. The yields of the voltage sensor under both the regular and inadequacy states are recorded.

If the MMC is under customary express, the yield of the voltage sensor would be zero on the inserted state and identical the capacitor voltage vc on the dodge state. At the point when a T1 issue occurs with the situation with S=1 and iarm<0, the current way would move to way 4, and the yield of the voltage sensor would ascend to the capacitor voltage vc, instead of nothing. At the point when a T2 deficiency occurs with the situation with S=0 and iarm>0, the current way would move to way 2, and the yield of the voltage sensor would be zero, as opposed to capacitor voltage vc.

Considering the Boolean reasoning movement, an inadequacy marker is introduced for the existingissue discovering strategy. First thing, the yield of the voltage sensor is binarized instead of the conscious worth. The binarized yield of the voltage sensor could be communicated, as Where vsn is the paired yield of the voltage sensor, v0 is the reference voltage of the capacitor for capacitor voltage adjusting control.

$$\begin{cases} v_{sn} = 0 & (\frac{v_s}{v_0} < 0.5) \\ v_{sn} = 1 & (\frac{v_s}{v_0} \geq 0.5) \end{cases}$$

VII. RESULT AND DISCUSSION

The hardware prototype is developed for 60 watts. The input to the MMC converters 12v DC supply.12-0-12v/3 A step down transformer is used to provide the power unit to the whole circuit. Here the ac supply is converted into dc supply by using bridge rectifier. Three different Output voltages are generated through this prototype.

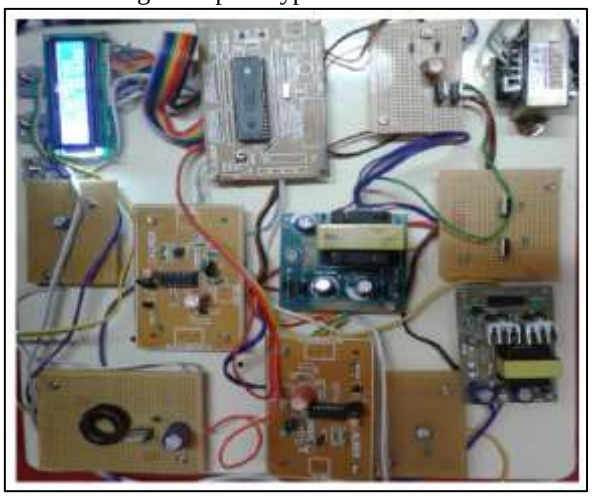


Fig. 2: Hardware prototype MMC converter monitoring

A. *Stage 1:12V-24V DC:*

In this stage normal boost converter is designed to get desired output voltage. Required Switching frequency is achieved

with the help of 3525 discrete PWM generator. A closed loop system was applied for stable constant output.

B. Stage 1:12V-48V DC:

In this stage 12v dc input is converted into 48v dc output. Here Fly back converter design is used. It provides electrical isolation between input and output. It consists of mosfets, coupled inductor, output diode and capacitor. In continuous conduction mode it delivers maximum output power. We can use this as charger for electrical vehicle.

C. Stage 3: 12v-240v DC

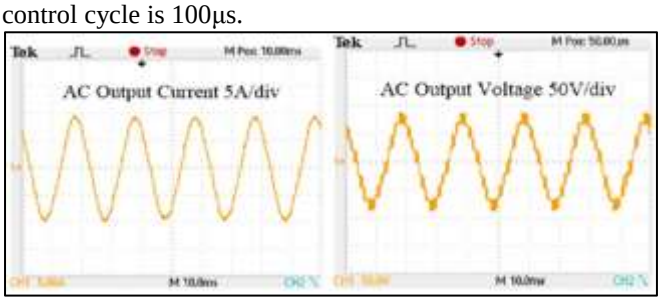
The circuit was designed with the help of fly back converter. Maximum output power this circuit is less than 100W. Driving circuit is an integrated with 3525 PWM generator IC. The switching element is a MOSFET. Supply operates in discontinuous current mode (DCM), which reduces the reverse recovery loss of diodes. These ultrafast diodes are used to rectify the secondary voltage. The current is sensed using a current transformer Tr2, because of direct sensing would cause excessive loss. The converter works with over 50% duty cycle. It is good for transformer converters with low input voltage (longer pulse of lower current causes less loss of these MOSFET than the shorter pulse of higher current).

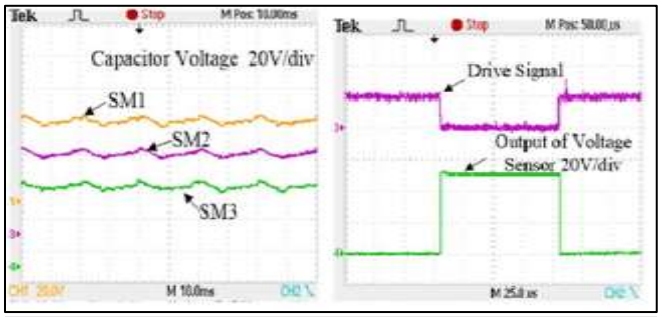
Pic micro controller is used to read the status of 3 stage output. All dc output is stepped down by using voltage divider rule and then the result is given to the pic micro controller. These result were connected to respective analog pins A0, A1 and A2. 16*2 LCD display is connected to PORT B. It supposed to read these analog data and then calibrated output will be displayed. The whole circuit is worked 5V dc supply. 12 v dc supply is then converted into 5v dc supply with the help ic 7805 voltage regulator.

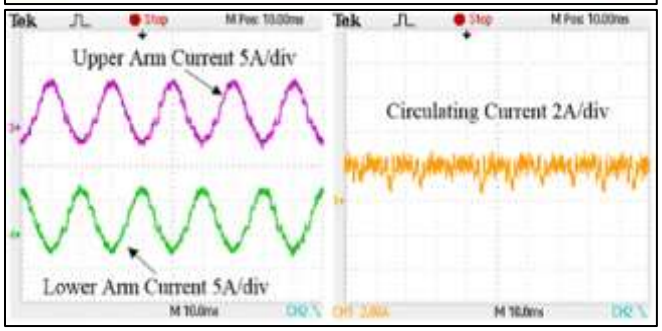
VIII. Experiment Validations

To confirm the viability of the proposed shortcoming finding procedure and capacitor checking technique, a research facility scaled single-stage MMC stage with four sub modules in each arm is set up in light of the even structure of three-stage MMC.

The voltage sensor should quantify a stage change waveform. Nonetheless, the prerequisite for the transmission capacity of the voltage sensor isn't high, since at the avoided express the yield of voltage sensor is utilized to restore the underlying voltage vc0, and at the embedded express the yield of voltage sensor is just barely a marker of the shortcoming. At that point a voltage sensor with 40µs reaction time is received in this test stage where the control cycle is 100µs.

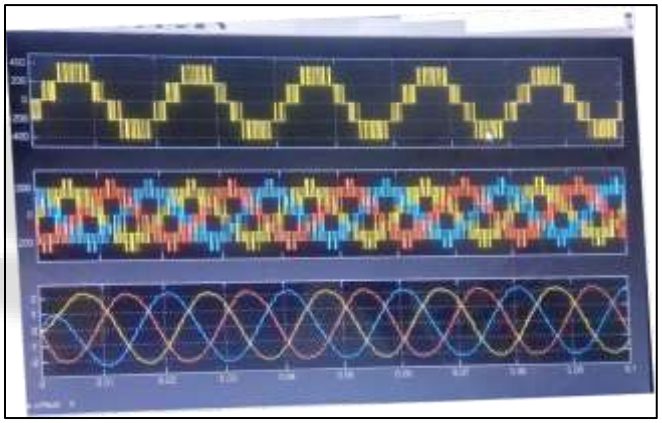






Experiment results under normal state

IX. Simulation Result



X. Conclusion

The Alternate Arm Converter is a mixture geography between the 2-level converter and the particular staggered converter. By joining piles of H-connect cells with chief switches it can create practically symphonious free AC current, as does the particular staggered approach, and by enacting just one arm for each half-cycle, similar to the 2-level converter, it very well may be worked with less cells than the MMC. Since this geography incorporates cells with capacitors which are exchanged into the current way, uncommon consideration should be paid to keeping their put away energy stockpiling (proportionately, the cell capacitor voltage) from floating away from their ostensible worth. By looking at the conditions which administer the trading of energy between the AC and DC-sides, an ideal working condition has been distinguished, called the "sweet spot". At the point when the converter is running at this condition, the energy levels of the stacks get back to their underlying qualities toward the finish of each cycle with no extra activity. In situations where this harmony isn't achieved, a cover period can be utilized to run a little DC current to adjust the

stacks by sending the overabundance of energy back to the DC capacitors. A conversation of the absolute number of gadgets needed by this geography has likewise been introduced. Giving DC-issue impeding and cover both require more than the absolute minimum number of cells and adding cells prompts expanded conduction power misfortune which leads to a plan compromise. Recreations of a limited scale model show that this converter can convey both great execution under ordinary conditions, regarding proficiency and current waveform quality, and furthermore give quick reactions on account of AC-or DC-side flaws. Its capacity to keep control of the current in any event, during DC shortcomings is a critical benefit, particularly in multi-terminal HVDC applications, and can be reached out into STATCOM activity to help the AC network during the blackout, by giving possibly up to 2.0 p.u. receptive current.

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