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Study of Silicon Controlled Rectifier Devices with Different Modes of Operation

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Abstract:

This study especially suggests the effect of size adjustments of silicon managed rectifier (SCR) gadgets on ESD protection. Based on 110-nm era node, the important thing parameters D1, D2, and D3 of SCR tool are variable to acquire the applicable measurement. Further, the element evaluations from the attitude of high-voltage utility for those measured consequences are summarized on this paintings.

Keywords- About four key words or phrases in alphabetical order, separated by commas. Keywords are used to retrieve documents in an information system such as an online journal or a search engine

Keywords **— Silicon Controlled Rectifier (SCR), SCR turn On methods, SCR turn off method**

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I. INTRODUCTION

This Component-stage ESD safety could be very essential in IC layout field. The gadgets gate-grounded NMOS (ggNMOS), diode and silicon managed rectifier (SCR) are frequently-used safety ones to discharge the component-stage ESD stresses like human frame model (HBM) . Among those styles of gadgets, SCR is extensively utilized in ESD safety layout because of its sturdy discharge potential and occasional leakage current [. From the angle of excessive-voltage application, it's far tremendously smooth for SCR to fulfill the necessities of excessive triggering voltage (Vt1). However, because of SCR snapback characteristic, low retaining voltage (Vh) or deep snapback is continually the hassle for excessive-voltage safety . To this end, a few current works display the answers for the hassle of low retaining voltage. For example, a floating-n-nicely vicinity is introduced to boom the discharging direction of ESD currents, which ends up in the boom of the retaining voltage . An unsymmetrical multi-finger SCR tool is designed that could successively be caused with the aid of using ESD pressure, a good way to boom the on-resistance.

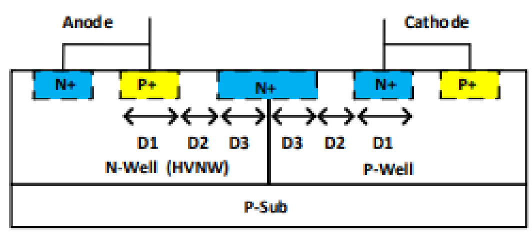

Fig.1. Structure of conventional MLSCR device.

Due to the equal avalanche breakdown current, the retaining voltage is increased. Among many methods, the only one is to boom the duration of the SCR, because of this that the boom of the space of the release direction . Then, an appropriate length of the SCR tool may be implemented to excessive voltage safety the usage of the stack method . As proven in Fig. 1, it describes a traditional changed lateral SCR tool (MLSCR) . N-Well vicinity is optionally changed with the aid of using HVNW. N+ among N-Well and P-Well is used to alternate the breakdown region for the junction. Specifically, the avalanche breakdown of reversed N+P junction can update that of the reversed NP junction. By this means, the junction may be caused with the aid of using ESD pressure easily. In Fig.1, extending D1, D2 and D3 is to boom the duration of the SCR as cited above. This paintings does now no longer recognition at the layout for a excessive sufficient Vh or a appropriate Vt1. Meanwhile, for the modifications of size D1, D2 and D3, the results on Vt1 and Vh were mentioned in element in current paintings [11]. Thus, similarly to Vt1 and Vh, this paintings in particular indicates the results on 2nd breakdown current (It2) for the parameters D1, D2 and D3. Moreover, the applicable discussions are primarily based totally at the measured outcomes with 110-nm era Node.

II. LITERATURE SURVEY

M. Paul, B. Sampath Kumar, K. Karmel Nagothu, P. Singhal, H. Gossner and M. Shrivastava",[1]. This article provides device design insights into drain-enhanced FinFET devices that incorporate electrostatic discharge (ESD) protection devices and silicon controlled rectifiers (SCRs) (DeFinFETSCRs) used as self-protected high-voltage switches / drivers. Describes design challenges. System on Chip-You can use the application.

"F. Zhang et al", [2]. This publication reports a new cell-by-cell type SCR-ESD structure in which ESD devices are formed on the four edges of SCR cells for higher layout efficiency and smoother ESD discharge. This new cell-by-cell SCRESDS structure has been validated in Foundry 28nm CMOS and exhibits excellent ESD protection performance when measured.

"Y. Huang and M. Ker", [3]. Based on good electrostatic discharge (ESD) resistance, silicon controlled rectifiers (SCRs) are used for on-chip ESD protection. The main concern with SCR is the latch-up problem caused by the low holding voltage.

"P. Tan, F. Chen, Z. Hu, D. Lou and Z. Zhang ", [4]. Closed-loop SCR control strategies are studied, PI control strategies are introduced, closed-loop SCR control system models are built, and simulations are performed..

"T. -Y. Lan, S. -L. Chen, Y. -J. Zhou, S. -Z. Hong, J. -Y. Lai and Z. -W. Liu" [5]. Due to the low R dson , an LDMOS parasitic SCR will cause the problem of low component holding voltage. In this paper, the modulations are divided into two categories. The first modulation embedded parasitic SCR and second modulation embedded the Schottky diode

"P. Galy, J. Bourgeat, J. Jimenez, C. Entringer, A. Dray and B. Jacquier", [6]. The main purpose of this document is to show and compare the results of silicon with C45nm CMOS technology for single-pitch ESD protection and isolated silicon controlled rectifiers (SCRs) and double-insulated SCRs.

"W. Song, Z. Liu and J. J. Liou", [7]. The proposed MLDMOS SCR has a low trigger voltage and a high holding voltage, making it very suitable for 18V / 20V ESD applications.

"Zhankai Li et al", [8]. This document primarily describes SCR valve protection techniques during high speed transients. It processes parameters such as SCR voltage, current, and temperature obtained through multiple paths in parallel with the high-speed logic judgment device.

"H. Liang, X. Gu, S. Dong and J. J. Liou", [9]. The proposed LDMOS SCRHHC is an attractive device for building effective, latch-up resistant ESD protection solutions for high voltage I / O ports.

"Y. Xu, Q. Jin and J. Yuan", [10]. Designing and developing an SCR system is a complex process that requires optimization of several parameters, including: B. Ammonia injection strategy, gateleaf geometric design, and monolithic SCR catalyst performance.

"Q. Yinggui", [11]. In this model, SCR energy is measured by three indicators: economic loss, loss of product function, and loss of corporate fame. Therefore, the risk energy of SC is measured and analyzed accordingly.

"K. Do and Y. Koo", [12]. The proposed ESD protection device has an additional parasitic NPN bipolar transistor that provides a very short ESD discharge path. It has excellent ON resistance and improved blocking characteristics compared to the conventional LowVoltage Trigger SCR (LVTSCR) and LowRon SCR (LRSCR). In addition, the trigger voltage and withstand voltage characteristics have been structurally improved.

"H. Xiaozong, L. Zhiwei, L. Fan, C. Hui and J. J. Liou", [13]. Describes the operating mechanism of the device and analyzes the effect of the inserted P + / N + diffusion region on the SCR with the TLPIV property.

"Y. Shan, J. He, B. Hu, J. Liu and W. Huang ", [14]. A new Silicon Controlled Rectifier (SCR) has been proposed, implemented in the foundry's 0.18mum CMOS process for electrostatic discharge (ESD) protection.

"N. K. Kranthi, B. S. Kumar, A. Salman, G. Boselli and M. Shrivastava", [15]. This article deals with the turn-on vulnerability of traditional LDMOS SCR devices in standard circuit operation windows. This behavior correlates with the initial ESD / SoA failure of HVLDMOSSCR devices and power-to-failure scalability issues.

III. METHODOLOGY

A. *SCR Turn ON Methods*

Leaks from the SCR will explode while the mold temperature can be very high. This makes the SCR conductive. If the time flow through the tool is very small, then α1 and α2 will be very small. The overvoltage situation is that the values of the photomultiplier tube Mn and the hollow multiplier tube Mp near the junction J2 are large. Therefore, if the overvoltage VBO is interrupted using the voltage rise of the entire tool, the J2 junction will collapse and the SCR will be turned on, as shown in Figure 2.

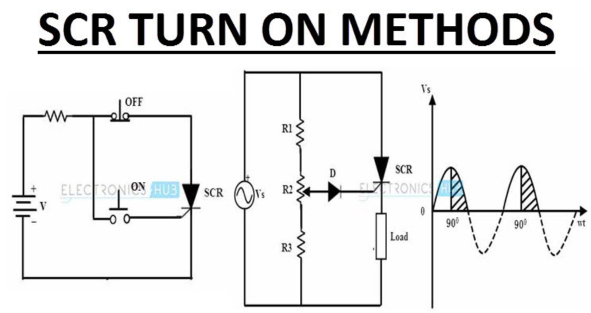

Fig.2. SCR turns on method

B. *SCR Turn OFF Methods*

You cannot turn off SCR through a gated connection as you would when the system is on. To turn off the SCR, the anode blade must be lowered to a level below the SCR holding blade. The system that turns off SCR is called commutation, as shown in Figure 3. Figures 4 and 5 show two major commutation types of SCR.

1. Natural Commutation and
2. Forced Commutation

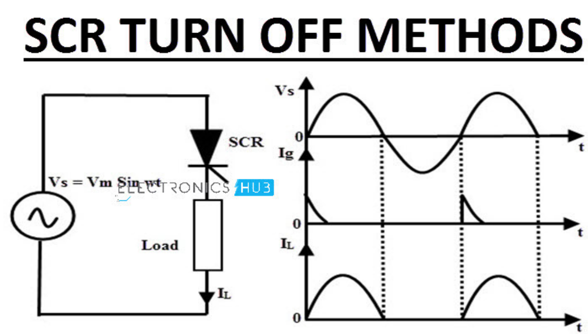

Fig.3. SCR turns off method

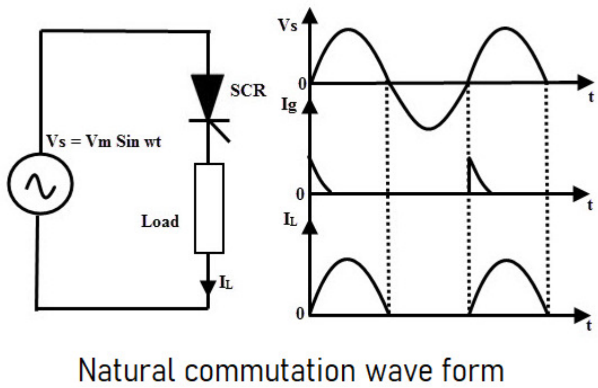

Fig.4. Natural Commutation method

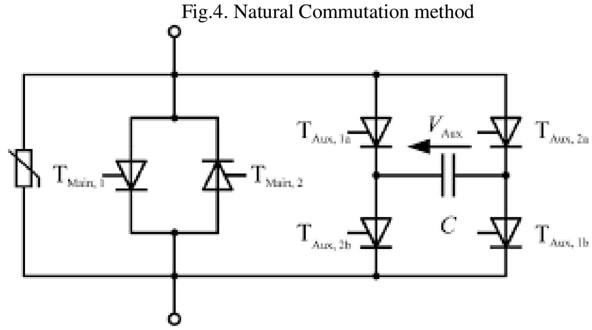

Fig.5. Forced Commutation method

IV. ADVANTAGES AND APPLICATION

A. ADVANTAGES

- It can handle large voltages, currents, and power.
- The voltage drop across conducting SCR is small.
- Easy to turn on.
- The operation does not produce harmonics.
- Triggering circuits are simple.
- It has no moving parts.
- It gives noiseless operation at high efficiency.

B. Applications

- ***AC Motor Control Using SCR***

The AC induction motor is controlled by the various stator voltages applied to it. The following decisions show the relationship of SCR to the various voltages applied to the stator of an induction motor. Each segment contains antiparallel SCRs, one for high quality tops and one for terrible tops. Therefore, six SCR configurations are commonly used to generate variable power. Three-segment AC power is supplied to the three-segment induction motor through these thyristors. When these SCRs are induced by delayed pulses, the average voltage applied to the induction motor changes, and therefore the speed.

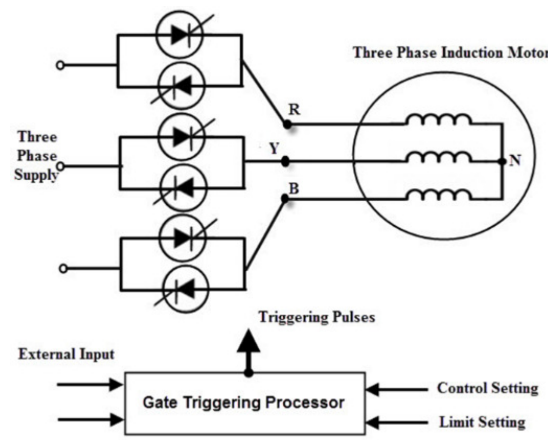

Fig.6. AC Motor Control Using SCR

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- The silicon controlled rectifier (SCR) is used in AC voltage stabilizers.
- The silicon controlled rectifier (SCR) is used as switch.
- It is used in choppers.
- The silicon controlled rectifier (SCR) is used in inverters.
- The silicon controlled rectifier (SCR) is used for power control.
- It is used for DC circuit breaker.
- Silicon control rectifier (SCR) is used in battery charger.
- It is used to Adjust light dimmer.
- It is used to control motors speed.
- The SCR is used in pulse circuit.

V. CONCLUSIONS

This figure specifically summarizes the effect of versions of the MLSCR magnitude parameters D1, D2, and D3 on ESD characteristics, primarily based entirely on the 100ns TLP test. The D1 alternative does not have a noticeable effect on the key values in the ESD window, including the retention of voltage (Vh) and secondary breakdown current (It2). The growth of D2 and D3 has the same effect on the trigger voltage (Vt1) and Vh, but it is a development dedicated to It2. A special assessment for exclusive It2 development also requires a TCAD simulation within the image of fate. In overvoltage applications, it may also be necessary to extend the tool life to detect excess Vh. From the measured results, D2 can be a higher preference due to the fact it may make certain the release potential of MLSCR tool at the same time as increasing.

REFERENCES

[1] M. Paul, B. Sampath Kumar, K. Karmel Nagothu, P. Singhal, H. Gossner and M. Shrivastava, "Drain-Extended FinFET With Embedded SCR (DeFinFET-SCR) for High-Voltage ESD Protection and Self-Protected Designs," in IEEE Transactions on Electron Devices, vol. 66, no. 12, pp. 5072-5079, Dec. 2019, doi: 10.1109/TED.2019.2949126.

[2] F. Zhang et al., "Cell-by-Cell SCR ESD Protection Structures in 28nm CMOS," 2019 Electron Devices Technology and Manufacturing Conference (EDTM), 2019, pp. 327-329, doi: 10.1109/EDTM.2019.8731126.

[3] Y. Huang and M. Ker, "A Latchup-Immune and Robust SCR Device for ESD Protection in 0.25-μm 5-V CMOS Process," in IEEE Electron Device Letters, vol. 34, no. 5, pp. 674-676, May 2013, doi: 10.1109/LED.2013.2252456.

[4] P. Tan, F. Chen, Z. Hu, D. Lou and Z. Zhang, "Closed-loop control strategy of NH3-SCR for diesel engines," 2011 International Conference on Electric Information and Control Engineering, 2011, pp. 5748-5752, doi: 10.1109/ICEICE.2011.5777076.

[5] T. -Y. Lan, S. -L. Chen, Y. -J. Zhou, S. -Z. Hong, J. -Y. Lai and Z. -W. Liu, "Holding-voltage Improvement of UHV Circular nLDMOS Transistors by the Drain-side SCR Engineering," 2021 IEEE International Conference on Consumer Electronics-Taiwan (ICCE-TW), 2021, pp. 1-2, doi: 10.1109/ICCE-TW52618.2021.9602930.

[6] P. Galy, J. Bourgeat, J. Jimenez, C. Entringer, A. Dray and B. Jacquier, "Comparison between isolated SCR & embedded dual isolated SCR power devices for ESD power clamp in C45nm CMOS technology," 2010 IEEE International Conference on Integrated Circuit Design and Technology, 2010, pp. 47-50, doi: 10.1109/ICICDT.2010.5510292.

[7] W. Song, Z. Liu and J. J. Liou, "A Modified LDMOS-SCR with High Holding Voltage for high voltage ESD Protection," 2019 8th International Symposium on Next Generation Electronics (ISNE), 2019, pp. 1-3, doi: 10.1109/ISNE.2019.8896592.

[8] Zhankai Li et al., "SCR series technology based on high-speed transient protection," 2011 1st International Conference on Electric Power Equipment - Switching Technology, 2011, pp. 657-660, doi: 10.1109/ICEPE-ST.2011.6122905.

[9] H. Liang, X. Gu, S. Dong and J. J. Liou, "RC-Embedded LDMOS-SCR With High Holding Current for High-Voltage I/O ESD Protection," in IEEE Transactions on Device and Materials Reliability, vol. 15, no. 4, pp. 495-499, Dec. 2015, doi: 10.1109/TDMR.2015.2463120.

[10] Y. Xu, Q. Jin and J. Yuan, "CFD simulations of gate leaves design in the SCR-DeNOx facility for coal-fired power plant," Proceedings of the 30th Chinese Control Conference, 2011, pp. 5868-5872.

[11] Q. Yinggui, "Research on the energy measurement model of SCR transfer," 2013 6th International Conference on Information Management, Innovation Management and Industrial Engineering, 2013, pp. 177-180, doi: 10.1109/ICIII.2013.6702903.

[12] K. Do and Y. Koo, "A New SCR Structure With High Holding Voltage and Low ON-Resistance for 5-V Applications," in IEEE Transactions on Electron Devices, vol. 67, no. 3, pp. 1052-1058, March 2020, doi: 10.1109/TED.2020.2963994.

[13] H. Xiaozong, L. Zhiwei, L. Fan, C. Hui and J. J. Liou, "High holding voltage SCR with shunt-transistors to avoid the latch-up effect," 2016 IEEE International Nanoelectronics Conference (INEC), 2016, pp. 1-2, doi: 10.1109/INEC.2016.7589357.

[14] Y. Shan, J. He, B. Hu, J. Liu and W. Huang, "NLDD/PHALO-Assisted Low-Trigger SCR for High-Voltage-Tolerant ESD Protection Without Using Extra Masks," in IEEE Electron Device Letters, vol. 30, no. 7, pp. 778-780, July 2009, doi: 10.1109/LED.2009.2022350.

[15] N. K. Kranthi, B. S. Kumar, A. Salman, G. Boselli and M. Shrivastava, "Performance and Reliability Co-design of LDMOS-SCR for Self-Protected High Voltage Applications On-Chip," 2019 31st International Symposium on Power Semiconductor Devices and ICs (ISPSD), 2019, pp. 407-410, doi: 10.1109/ISPSD.2019.8757641.