Dependability in Electronic Systems

Nobuyasu Kanekawa · Eishi H. Ibe · Takashi Suga · Yutaka Uematsu

Dependability in Electronic Systems

Mitigation of Hardware Failures, Soft Errors, and Electro-Magnetic Disturbances

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Preface

The word “dependability” that appears in the title is not used so often to be familiar with. The word has wider meaning and not only means “reliability” but also includes robustness, safety, security, resilience, and so on. Fault-tolerance technology that equips the redundant subsystems or components in preparation for failure in order to improve “reliability” has been used for many decades. In the meantime, J.C. Laprie expanded the term dependability as a wider concept in 1985 [1] because the meaning of “reliability” that the fault-tolerance technology treated had broadened. After then, dependability and dependable have been used in various fields to this day. Based on such situation and as I also belonged to the committees concerning “dependability,” I dare to use “dependability” in this text, thinking it is one of my vocations to spread the term.

As for terms related to reliability, the two terms have been used exclusively in Japanese. The Japanese word *shinrai-do* means quantitative index of reliability and the word *shinrai-sei* means qualitative character of reliability. In my personal opinion, the *shinrai-sei* may fall on the dependability.

As written in the title of this book, mitigation of hardware failures, soft errors, and electro-magnetic disturbances is indispensable in order to realize dependability of electronic systems. This book introduces authors’ original mitigation technologies of soft errors, electro-magnetic interference, and power supply noise, in addition to general mitigation technologies.

The authors have brought up the mitigation technology to realize dependability through a lot of industrial fields such as railroad, atomic energy, and IT networks. The dependable technology starts unifying with the latest LSI technology and being succeeded by the safety processor technology by on-chip redundancy. As a result, great reduction in costs will become possible by the effect of mass production of LSI technology in the future. I am convinced that we can contribute to safety and convenience of our ordinary life using dependable technology in more falimiar field such as automotives.

Lake Hatori, Japan

Nobuyasu Kanekawa
3rd May, 2010

Reference

1. J.C. Laprie, “Dependable Computing and Fault Tolerance: Concepts and Terminology,” *Proceedings of the 15th IEEE International Symposium on Fault-Tolerant Computing, Austin, TX, USA*, pp. 2–11 (1985).

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After the correction of the text, the authors were informed news with the deepest sadness. We would like to pay a tribute to the memory and contribution of the late Dr. J. C. Laprie, who advocated the term “dependability” ([1] in Preface).

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List of Acronyms

ACCM	AC common-mode conversion
ALARP	as low as reasonably practicable
ATP	automatic train protection
BGA	ball grid array
BOM	bill of materials
BQF	bypass quality factor
CDR	clock data recovery
CHB	checker board
CHBc	checker board complement
CMRR	common-mode reduction ratio
CORIMS	cosmic radiation impact simulator
COTS	commercial off-the-shelf
DDR	double data rate
DMAC	direct memory access controller
DOA	design on average
DOAV	design on average and variation
DOUB	design on upper bound
DRAM	dynamic random access memory
ECC	error correction code
EMC	electromagnetic compatibility
EMI	electromagnetic interference
ENIAC	electronic numerical integrator and computer
ESL	equivalent series resistance
ESL	equivalent series inductance
ESR	equivalent series resistance
FDTIM	frequency-domain target impedance meter
FIT	failure in time, failure unit
FPGA	field programmable gate array
FTMP	fault-tolerant multi-processor
GND	ground
HMR	hybrid modular redundancy
IFDIM	integrated power-supply frequency-domain impedance meter

ISAS	Space and Astronautical Science of Japan, currently Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (JAXA)
ISI	inter-symbol interference
JAXA	Japan Aerospace Exploration Agency
JPL	jet propulsion laboratory
LSI	large-scale integrated circuit
MASR	modified asymmetrical slew rate
MBU	multi-bit upset
MCBI	multi-coupled bipolar interaction
MCP	multi-chip package
MCU	multi-cell upset
MFTF	mean fluence to failure
MOS	metal oxide semiconductor
MTTF	mean time to failure
MTTR	mean-time to repair, or mean-time to restoration
NMR	N-tuple modular redundancy
OBC	onboard computer
OLTP	online transaction processor
OSPM	operating system power management
PCB	printed circuit board
PCSE	power cycle soft error
PDN	power distribution network
PDS	power distribution system
PI	power integrity
PKG	package
PLL	phase locked loop
PoP	package on package
PWL	piecewise linear
RAM	random access memory
RF	radio frequency
SBU	single-bit upset
SDRAM	synchronous dynamic access memory
SEB	single-event burnout
SEFI	single-event functional interruption
SEGR	single-event gate rupture
SEL	single-event latchup
SER	soft-error rate
SESB	single-event snap-back
SEU	single-event upset
SIFT	software implemented fault tolerance
SIL	safety integrity level
SNV	stepwise negotiating voting
SPICE	simulation program with integrated circuit emphasis
SRAM	static random access memory

SSN	simultaneous switching noise
STAR	self-testing and repairing
TMR	triple modular redundancy
TRON	the real-time operating system nucleus
TTP	time-triggered protocol
USEF	Institute for Unmanned Space Experiment Free Flyer
VRM	voltage regulator module
ZIR	zero-input response
ZSR	zero-state response