

Contents

Chapter 1 Introduction	1
1.1 Background.....	1
1.2 Motivation.....	2
1.3 Organization.....	3
Chapter 2 An Overview of Content Addressable Memory	5
2.1 Conventional CAM Architecture	5
2.2 Conventional CAM Cell	6
2.2.1 Binary CAM Cell.....	6
2.2.2 Ternary CAM Cells.....	8
2.3 Match-line Structure	11
2.3.1 NOR-type Match-line	12
2.3.2 AND-type Match-line	12
2.4 Applications of CAM.....	13
2.4.1 Cache Memory.....	14
2.4.2 Translation Look-aside Buffer	15
2.4.3 Packet Forwarding Using CAM.....	16
2.4.4 ATM Switches	18
2.5 Low power Content-addressable Memory Designs.....	19
2.5.1 Method of reducing Match-line power consumption.....	19
2.5.1.1 Low-Swing Scheme	19
2.5.1.2 Current-Race Scheme	20
2.5.1.3 Selective-Precharge Scheme	21
2.5.1.4 Pipelining Scheme	22
2.5.1.5 Current-Saving Scheme	23
2.5.2 Method of reducing Search-line power consumption.....	24
2.5.2.1 Hierarchical Search-line Scheme	24
2.5.2.2 Charge-Recycling Search-line Driver.....	26
2.5.3 Power-Saving CAM architecture	27
2.5.4 Tree Style AND-type Match Lines	30
2.6 Method of Reducing Standby Power	33
2.6.1 Novel Storage Cells for TCAM	33
Chapter 3 Multi-Mode Power Gating Technique.....	36
3.1 Standby Power	36
3.2 Stacking Effect.....	40
3.2.1 Self-Reverse Biasing.....	40
3.2.2 Trade-off Between Delay and Leakage.....	41

3.3 Power Gating Structures with Concurrent Data Retention and Intermediate mode.....	42
3.4 Proposed Power Gating Structure	46
3.4.1 Multi-mode Data Retention Power Gating Technique.....	46
3.4.2 Noise Margin Analysis.....	47
3.4.3 Simulation Result and Comparisons	48
3.5 Summary	49
Chapter 4 Low Power Schemes for Energy-Efficient TCAM Design	51
4.1 IPv6 Addressing Architecture	52
4.1.1 Unspecified Unicast Addresses.....	53
4.1.2 Loopback Unicast Addresses	53
4.1.3 Global Unicast Addresses	53
4.1.4 Local-Use IPv6 Unicast Addresses.....	54
4.2 IP Address Lookup.....	54
4.3 IPv6 Prefix Length Distribution in The Router	57
4.4 Energy Efficient Ternary Content Addressable Memory.....	58
4.4.1 Butterfly Match-Line Scheme.....	59
4.4.2 XOR-Based Conditional Keeper.....	60
4.4.3 Don't Care Based Power Gating Match-line Scheme.....	62
4.4.4 Don't Care Based Hierarchical Search-Line Scheme.....	63
4.5 Architecture.....	64
4.5.1 Match-line Scheme	66
4.5.1.1 Butterfly AND-type Match-line Scheme for IPv6.....	66
4.5.1.2 Applying Don't-care Based Power-Gating Technique.....	67
4.5.2 Ternary CAM Cell	68
4.5.3 Don't-care Based Hierarchical Search-line Scheme for IPv6.....	70
Chapter 5 Super Cut-off Power Gating TCAM Design with Leakage Current Reduction	71
5.1 Power Sources in Digital CMOS Circuits	72
5.1.1 Dynamic Power.....	72
5.1.2 Short-Circuit Power	72
5.1.3 Leakage Power.....	72
5.1.4 Low-Power CAM Design	73
5.2 MOSFET Structure Capacitances	73
5.2.1 Gate Capacitances.....	73
5.2.1.1 Overlap Capacitances.....	74

5.2.1.2 Gate-to-Channel Capacitances.....	75
5.2.2 Junction Capacitances.....	76
5.2.2.1 Bottom-Plate Junction Capacitances.....	76
5.2.2.2 Side-Wall Junction Capacitances.....	77
5.3 Super Cut-off Power Gating TCAM Structure	77
5.3.1 Introduction to Super Cut-off Technique.....	78
5.3.1.1 Concept of Super Cut-off Technique	78
5.3.1.2 Zigzag Super Cut-off Technique.....	79
5.3.2 Proposed Super Cut-off Power Gating Technique.....	82
5.3.2.1 Architecture.....	82
5.3.2.2 Implementation of Control Circuits and Voltage Generator	83
5.3.3 Simulation Result and Analysis	84
5.4 Proposed Low Power Ternary Content-Addressable Memory	87
5.4.1 Multi-mode Data Retention Power Gating Technique	87
5.4.2 Super Cut-off Power Gating Technique.....	89
5.4.3 The Overall Architecture.....	90
5.5 Simulation Result and Comparisons.....	90
5.6 Layout and the Post-Simulation.....	93
5.7 Summary	95
Chapter 6 Conclusions.....	97
6.1 Conclusions.....	97
Bibliography	99

