



A Universal Flash Controller Instruction Set

Michael Etzkorn, SoC Architect
Sage Microelectronics

Motivation

- There is variety among NAND flash vendor designs
- NAND flash commands can require dedicated hardware for vendor differences
- Over 200 vendor specific commands!

Type	Opcode
Standard Command Set	00h, 05h – 06h, 10h – 11h, 15h, 18h, 30h – 32h, 35h, 3Fh, 60h, 62h – 64h, 70h, 76h, 78h, 80h – 81h, 85h, 90h, 1Bh – 1Ch, D0h – D1h, D4h – D5h, D9h, E0h – E2h, ECh – EFh, F1h – F2h, F9h, FAh, FCh, FFh
Vendor Specific	01h – 04h, 07h – 0Ah, 0Ch – 0Fh, 13h, 16h – 17h, 19h – 1Ah, 1Dh – 2Fh, 33h – 34h, 36h – 3Eh, 40h – 5Fh, 61h, 65h – 6Fh, 71h – 75h, 77h, 79h – 7Fh, 84h, 87h – 8Dh, 8Fh, 91h – CFh, D2h – D3h, D6h – D8h, DAh – DFh, E3h – EBh, F0h, F3h – F8h, FBh, FD – FEh
Reserved	0Bh, 12h, 14h, 82h – 83h, 86h, 8Eh

ONFI Spec 5.0

Table 5-2 Opcode Reservations

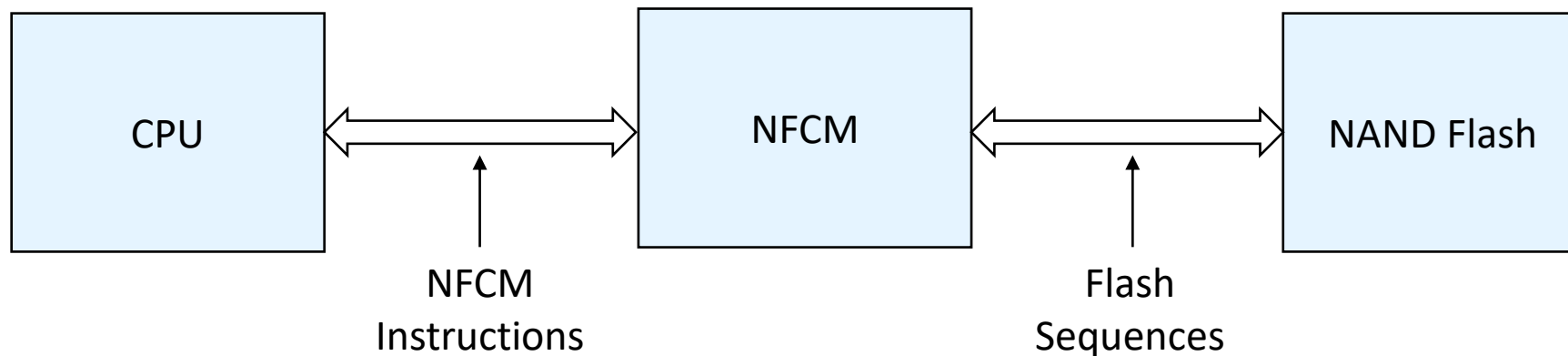


KIOXIA



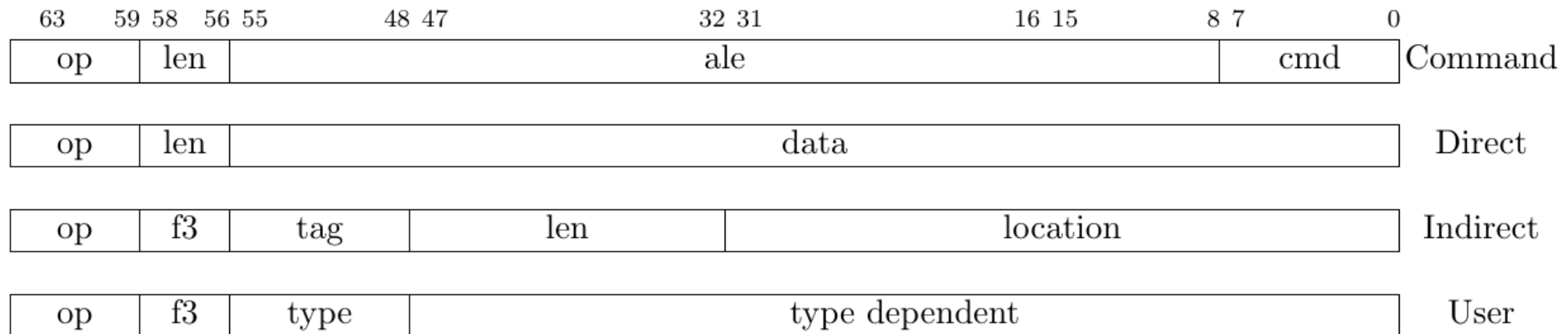
What is a Flash Controller Instruction Set?

- Instructions to be executed by a NAND Flash Controller Module (NFCM)
 - The instruction set should account for variation among vendors and forward compatibility with ONFI
 - Allows CPU to write a series of instructions and continue execution



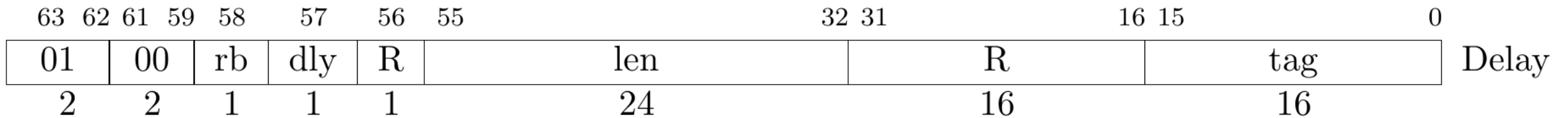
NFCM Sequence Instructions (NSQI)

- Goal: Interoperability between major NAND flash vendors
- Abstract flash sequences into sequences of NFCM instructions
- Four main formats of instruction



NSQI – User Instructions

- **Flexibility**
 - Allow FW controlled timing
 - Toggle GPIO pins
- **Utility**
 - Interrupt NFCM processing
 - CODEC and scrambler/descrambler operations



NAND chips from Two Flash Vendors

Vendor A

- SLC Mode – 0xDA
- Address Mode – 6 cycles

C1	C2	R1	R2	R3	R4
----	----	----	----	----	----

- Timing Parameters

Vendor B

- SLC Mode – 0x2A
- Address Mode – 5 cycles

C1	C2	R1	R2	R3
----	----	----	----	----

- Timing Parameters
- TLC operations prefixed by 0x01, 0x02, 0x03



Producing Instruction Sequences

- Two TLC program sequences for different vendor chips using NSQL

Command	User	Cascaded Indirect	Cascaded Indirect	Indirect
CMD ALE x6	Delay	Loc 0	Loc 1	Loc 2

Vendor A

Command	Direct	Cascaded Indirect
CMD ALE x5	01	Loc 0

Direct	Cascaded Indirect	Direct	Indirect
02	Loc 1	03	Loc 2

Vendor B

Benefits from an instruction set like NSQI

- Offloads firmware work by forming sequences out of instructions
- Universal support among NAND flash vendors
- Designed for forward compatibility

NSQI: A Universal Flash Controller Instruction Set

Thank you for listening!
Q&A