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## TLBI RVAAE1OS, TLBI RVAAE1OSNXS, TLB Range Invalidate by VA, All ASID, EL1, Outer Shareable

The TLBI RVAAE1OS, TLBI RVAAE1OSNXS characteristics are:

### Purpose

Invalidates cached copies of translation table entries from TLBs that meet all the following requirements:

- The entry is a 64-bit stage 1 translation table entry, from any level of the translation table walk up to the level indicated in the TTL hint.

Or if FEAT\_D128 is implemented, and the entry is a 128-bit stage 1 translation table entry, from any level of the translation table walk, if TTL is 0b00.

- The entry is within the address range determined by the formula  $[\text{BaseADDR} \leq \text{VA} < \text{BaseADDR} + ((\text{NUM} + 1) * 2^{(5 * \text{SCALE} + 1)} * \text{Translation\_Granule\_Size})]$ .
- When EL2 is implemented and enabled in the current Security state:
  - If [HCR\\_EL2](#).{E2H, TGE} is not {1, 1}, the entry would be used with the current VMID and would be required to translate any of the VAs in the specified address range using the EL1&0 translation regime for the Security state.
  - If [HCR\\_EL2](#).{E2H, TGE} is {1, 1}, the entry would be required to translate any of the VAs in the specified address range using the EL2&0 translation regime for the Security state.
- When EL2 is not implemented or is disabled in the current Security state, the entry would be required to translate any of the VAs in the specified address range using the EL1&0 translation regime for the Security state.

The Security state is indicated by the value of [SCR\\_EL3](#).NS if FEAT\_RME is not implemented, or [SCR\\_EL3](#).{NSE, NS} if FEAT\_RME is implemented.

The invalidation applies to all PEs in the same Outer Shareable shareability domain as the PE that executes this System instruction.

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**Note**

When a TLB maintenance instruction is generated to the Secure EL1&0 translation regime and is defined to pass a VMID argument, or would be defined to pass a VMID argument if [SCR\\_EL3.EEL2==1](#), then:

- A PE with [SCR\\_EL3.EEL2==1](#) is not architecturally required to invalidate any entries in the Secure EL1&0 translation of a PE in the same required shareability domain with [SCR\\_EL3.EEL2==0](#).
- A PE with [SCR\\_EL3.EEL2==0](#) is not architecturally required to invalidate any entries in the Secure EL1&0 translation of a PE in the same required shareability domain with [SCR\\_EL3.EEL2==1](#).
- A PE is architecturally required to invalidate all relevant entries in the Secure EL1&0 translation of a System MMU in the same required shareability domain with a VMID of 0.

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**Note**

For the EL1&0 and EL2&0 translation regimes, the invalidation applies to both global entries and non-global entries with any ASID.

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For 64-bit translation table entry, the range of addresses invalidated is unpredictable when:

- For the 4K translation granule:
  - If  $TTL==01$  and  $BaseADDR[29:12]$  is not equal to 000000000000000000.
  - If  $TTL==10$  and  $BaseADDR[20:12]$  is not equal to 000000000.
- For the 16K translation granule:
  - If  $TTL==10$  and  $BaseADDR[24:14]$  is not equal to 000000000000.

For the 64K translation granule:

- - If TTL==01 and BaseADDR[41:16] is not equal to 00000000000000000000000000000000.
  - If TTL==10 and BaseADDR[28:16] is not equal to 0000000000000000.

If FEAT\_XS is implemented, the nXS variant of this System instruction is defined.

Both variants perform the same invalidation, but the TLBI System instruction without the nXS qualifier waits for all memory accesses using in-scope old translation information to complete before it is considered complete.

The TLBI System instruction with the nXS qualifier is considered complete when the subset of these memory accesses with XS attribute set to 0 are complete.

## Configuration

This instruction is present only when FEAT\_TLBIRANGE is implemented and FEAT\_TLBIOS is implemented. Otherwise, direct accesses to TLBI RVAAE1OS, TLBI RVAAE1OSNXS are undefined.

## Attributes

TLBI RVAAE1OS, TLBI RVAAE1OSNXS is a 64-bit System instruction.

## Field descriptions

63	62	61	60	59	58	57	56	55	54	53	52	51	50	49	48	47	46	45	44	43	42	41	40	39	38	37	36	35	34	33	32		
RES0																TG	SCALE	NUM				TTL	BaseADDR										
BaseADDR																																	
31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		

### Bits [63:48]

Reserved, res0.

### TG, bits [47:46]

Translation granule size.

TG	Meaning
0b00	Reserved.
0b01	4K translation granule.
0b10	16K translation granule.
0b11	64K translation granule.

The instruction takes a translation granule size for the translations that are being invalidated. If the translations used a different

translation granule size than the one being specified, then the architecture does not require that the instruction invalidates any entries.

### **SCALE, bits [45:44]**

The exponent element of the calculation that is used to produce the upper range.

### **NUM, bits [43:39]**

The base element of the calculation that is used to produce the upper range.

### **TTL, bits [38:37]**

TTL Level hint. The TTL hint is only guaranteed to invalidate:

- Non-leaf-level entries in the range up to but not including the level described by the TTL hint.
- Leaf-level entries in the range that match the level described by the TTL hint.

<b>TTL</b>	<b>Meaning</b>
0b00	The entries in the range can be using any level for the translation table entries.
0b01	The TTL hint indicates level 1. If FEAT_LPA2 is not implemented, when using a 16KB translation granule, this value is reserved and hardware should treat this field as 0b00.
0b10	The TTL hint indicates level 2.
0b11	The TTL hint indicates level 3.

### **BaseADDR, bits [36:0]**

**When FEAT\_LPA2 is implemented and TCR\_EL1.DS == 1:**

The starting address for the range of the maintenance instructions. This field is BaseADDR[52:16] for all translation granules.

When using a 4KB translation granule, BaseADDR[15:12] is treated as 0b0000.

When using a 16KB translation granule, BaseADDR[15:14] is treated as 0b00.

### Otherwise:

The starting address for the range of the maintenance instruction.

When using a 4KB translation granule, this field is BaseADDR[48:12].

When using a 16KB translation granule, this field is BaseADDR[50:14].

When using a 64KB translation granule, this field is BaseADDR[52:16].

## Executing TLBI RVAAE1OS, TLBI RVAAE1OSNXS

Accesses to this instruction use the following encodings in the System instruction encoding space:

TLBI RVAAE1OS{, <Xt>}

op0	op1	CRn	CRm	op2
0b01	0b000	0b1000	0b0101	0b011

```
if PSTATE.EL == EL0 then
    UNDEFINED;
elsif PSTATE.EL == EL1 then
    if EL2Enabled() && HCR_EL2.TTLB == '1' then
        AArch64.SystemAccessTrap(EL2, 0x18);
    elsif EL2Enabled() && HCR_EL2.TTLBOS == '1' then
        AArch64.SystemAccessTrap(EL2, 0x18);
    elsif EL2Enabled() &&
        IsFeatureImplemented(FEAT_FGT) && (!HaveEL(EL3) ||
        SCR_EL3.FGTEn == '1') && HFGITR_EL2.TLBIRVAAE1OS ==
        '1' then
        AArch64.SystemAccessTrap(EL2, 0x18);
    else
        if IsFeatureImplemented(FEAT_XS) &&
        IsFeatureImplemented(FEAT_HCX) && IsHCRXEL2Enabled()
        && HCRX_EL2.FnXS == '1' then

        AArch64.TLBI_RVAA(SecurityStateAtEL(EL1),
        Regime_EL10, VMID[], Shareability_OSH,
        TLBILevel_Any, TLBI_ExcludeXS, X[t, 64]);
        else

        AArch64.TLBI_RVAA(SecurityStateAtEL(EL1),
        Regime_EL10, VMID[], Shareability_OSH,
        TLBILevel_Any, TLBI_AllAttr, X[t, 64]);
    elsif PSTATE.EL == EL2 then
        if HCR_EL2.<E2H,TGE> == '11' then
            AArch64.TLBI_RVAA(SecurityStateAtEL(EL2),
```

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Regime_EL20, VMID_NONE, Shareability_OSH,
TLBILevel_Any, TLBI_AllAttr, X[t, 64]);
else
    AArch64.TLBI_RVAA(SecurityStateAtEL(EL1),
Regime_EL10, VMID[], Shareability_OSH,
TLBILevel_Any, TLBI_AllAttr, X[t, 64]);
elseif PSTATE.EL == EL3 then
    if HCR_EL2.<E2H,TGE> == '11' then
        AArch64.TLBI_RVAA(SecurityStateAtEL(EL2),
Regime_EL20, VMID_NONE, Shareability_OSH,
TLBILevel_Any, TLBI_AllAttr, X[t, 64]);
    else
        AArch64.TLBI_RVAA(SecurityStateAtEL(EL1),
Regime_EL10, VMID[], Shareability_OSH,
TLBILevel_Any, TLBI_AllAttr, X[t, 64]);

```

## TLBI RVAAE10SNXS{, <Xt>}

op0	op1	CRn	CRm	op2
0b01	0b000	0b1001	0b0101	0b011

```

if !IsFeatureImplemented(FEAT_XS) then
    UNDEFINED;
elseif PSTATE.EL == EL0 then
    UNDEFINED;
elseif PSTATE.EL == EL1 then
    if EL2Enabled() && HCR_EL2.TTLB == '1' then
        AArch64.SystemAccessTrap(EL2, 0x18);
    elseif EL2Enabled() && HCR_EL2.TTLBOS == '1' then
        AArch64.SystemAccessTrap(EL2, 0x18);
    elseif EL2Enabled() &&
IsFeatureImplemented(FEAT_FGT) && (!HaveEL(EL3) ||
SCR_EL3.FGTEn == '1') &&
IsFeatureImplemented(FEAT_HCX) && (!
IsHCRXEL2Enabled() || HCRX_EL2.FGTnXS == '0') &&
HFGITR_EL2.TLBIRVAAE10S == '1' then
        AArch64.SystemAccessTrap(EL2, 0x18);
    else
        AArch64.TLBI_RVAA(SecurityStateAtEL(EL1),
Regime_EL10, VMID[], Shareability_OSH,
TLBILevel_Any, TLBI_ExcludeXS, X[t, 64]);
elseif PSTATE.EL == EL2 then
    if HCR_EL2.<E2H,TGE> == '11' then
        AArch64.TLBI_RVAA(SecurityStateAtEL(EL2),
Regime_EL20, VMID_NONE, Shareability_OSH,
TLBILevel_Any, TLBI_ExcludeXS, X[t, 64]);
    else
        AArch64.TLBI_RVAA(SecurityStateAtEL(EL1),
Regime_EL10, VMID[], Shareability_OSH,
TLBILevel_Any, TLBI_ExcludeXS, X[t, 64]);
elseif PSTATE.EL == EL3 then
    if HCR_EL2.<E2H,TGE> == '11' then
        AArch64.TLBI_RVAA(SecurityStateAtEL(EL2),

```

```
Regime_EL20, VMID_NONE, Shareability_OSH,  
TLBILevel_Any, TLBI_ExcludeXS, X[t, 64]);  
    else  
        AArch64.TLBI_RVAA(SecurityStateAtEL(EL1),  
Regime_EL10, VMID[], Shareability_OSH,  
TLBILevel_Any, TLBI_ExcludeXS, X[t, 64]);
```

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