Berry ZCN system manual

> Everything here requires the device to run in **Zigbee Hub** mode and SLZB-OS **v3.3.8.dev0** or **higher.**

This document describes the **Berry** side of the ZCN converter system: writing device-specific Zigbee Hub converters as Berry scripts, without rebuilding the firmware.

The concept of ZCN primarily refers to native C++ converters, but we decided to keep this name for Berry converters for simplicity. Actually Berry converters are not native, they are a scripting interface.

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1. What Berry ZCN is and when to use it

A Berry ZCN converter is the runtime-scriptable twin of a native `zcn_converter_t`: a description of how a specific Zigbee device deviates from standard ZCL handling — extra/proprietary attributes, remapped clusters, custom value normalization, custom MQTT/Home Assistant discovery — plus Berry callback functions that the hub invokes at the same points where native converters invoke C function pointers.

Use Berry ZCN when you want to:

- **Prototype** a converter for a new device without a firmware rebuild — iterate directly in the on-device script editor, then port the result to a native converter for shipping.
- **Support a device locally** that the stock firmware does not have a converter for.
- **Experiment** with normalization/serialization/discovery logic against a live device.

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2. Architecture and lifecycle

2.1 Slots

There are **(currently 2) slots** for Berry converters. Each registered converter occupies one slot. Registration fails with `"no free slots for ZCN"` when all slots are taken.

2.2 VM binding and garbage collection

- A converter belongs to the **VM that registered it**.
- All callback functions passed into the structure are **GC-pinned** while the converter exists, and unpinned on delete — you can use closures/anonymous `def` blocks safely.
- When a script's VM stops, **all its converters are automatically deleted**. Restarting the script re-registers them.

2.3 Attachment is NOT persisted — attach on every boot

This is the most important lifecycle difference from native ZCN:

- The native converter index is saved in the device database and restored on boot.
- The Berry converter index is **runtime-only**. It resets every boot and is set only by:
  1. **Interview matching** — during a device interview.
  2. **Explicit** `ZCN.attach(slot, ieee)` from your script.

Since interviews only run at pairing, a converter script must call `ZCN.attach()` for its devices every time it starts. The standard pattern:

```
var slot = ZCN.register(my_converter)
ZCN.attach(slot, "0x3425b4fffe12e9e9") # repeat for each device
```

Optional, run the script with autostart (`#META {"start":1}`) so the converter is registered and attached right after boot.

2.4 Priority over native converters

Berry converters take priority everywhere:

- **Interview matching**: all Berry slots are checked *first*; if one matches, is set and native matching is skipped.
- **Runtime dispatch**: every hook site checks `ZCN_CHECK_BE(dev)` before the native `ZCN_CHECK(dev)` — data handling, on_cmd, MQTT write/cmd, HA discovery, trigger discovery. A device can technically have both `zcn` and `zcn_be` set; the Berry one is consulted first wherever it provides an override.

2.5 Matching logic

- If the converter has a **`matcher` function** — it is called as `def (dev)` with a `ZigbeeDevice` instance and must return `true`/`false`. `model`/`manuf` strings are ignored.

- Otherwise — exact string compare of **both** `manuf` (Basic attr 0x0004) and `model` (Basic attr 0x0005) against the interviewed values.

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3. Quick start

The easiest way to produce a converter is the **ZCN Builder** page in the web UI (*Zigbee Hub → ZCN Builder*): assemble the structure in the form, pick callback presets, and copy the generated Berry code.

`ZCN.register()` validates the map, finds a free slot, and feeds the structure into the native slot. It returns the **slot number** (needed for `ZCN.attach`) and raises a descriptive error on failure (the partially built slot is deleted automatically).

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4. Converter map reference

The converter is a plain Berry `map`. Missing keys get defaults: **int → 0, string →** `""`**, bool →** `false`**, function →** `nil` (exceptions noted below). Extra/unknown keys are ignored.

4.1 Top level

Key	Type	Required	Meaning
`signature`	map	**yes** (raises otherwise)	Device matching, see below
`on_annonce`	function	no	Called when the device announces itself (power-on / rejoin)
`on_intw_stage`	function	no	Called before interview stages; see §5.2
`overrides_count`	int	yes, if `overrides` present	**Must equal** `overrides.size()` — it is not derived automatically
`overrides`	list of maps	no	Endpoint overrides

4.2 `signature`

The signature tells SLZB-OS whether this converter is suitable for the device for which the interview is currently being performed.

Key	Type	Meaning
`matcher`	function	If present, used instead of model/manuf. Must be a function
`model`	string	Zigbee model identifier (exact match via strcmp())
`manuf`	string	Manufacturer name (exact match)

4.3 Endpoint override (element of `overrides`)

Key	Type	Meaning
`endpoint`	int	Zigbee endpoint number this override applies to
`clusterCount`	int	Number of clusters in `clusters`
`clusters`	list of maps	Cluster object array

4.4 Cluster override (element of `clusters`)

Key	Type	Default	Meaning
`id`	int	0	ZCL cluster id (e.g. `0x0402`)
`addMode`	int	0	`0` = ADD (merge with the standard cluster: your attrs are used where ids collide, standard attrs fill the rest), `1` = OVERRIDE (standard cluster fully ignored; only your definition used)
`bind`	bool	false	Bind this cluster to the hub during interview
`attrCount`	int	0	Number of attributes in `attrs`
`attrs`	list of maps	—	Attribute objects array
`cmd_config`	map	—	Cluster **command** handling (buttons/actions), see below
`on_mqtt_cmd`	function	nil	Used for `cmd_config`. Handles MQTT messages on the `{base}/cmd/...` topic for this cluster. Return `true` = handled (standard handling skipped)

4.5 `cmd_config`

Tells SLZB-OS what actions(triggers) this cluster provides. Typically used for Zigbee buttons and scene remotes.

Key	Type	Meaning

`on_cmd`	function	Converts the received command record into an action string (e.g. `"btn_single"`). Must return a **string** to publish it as an action.
`exposes`	string	`"|"`-separated list of all possible action strings — used to generate device-trigger discovery
`exposesOverride`	function	Dynamic alternative to `exposes`: return the `"|"`-separated list at discovery time; empty-string return skips triggers for this cluster

Note: the command path is only taken when the cluster has `on_cmd` **and** at least one of `exposes` / `exposesOverride`.

4.6 Attribute override (element of `attrs`)

Key	Type	Default	Meaning
`id`	int	0	ZCL attribute id
`name`	string	""	Human-readable name (shown in web UI)
`mqttClass`	int	0	MQTT entity type, see table below
`mqttSubClass`	string	""	MQTT entity `device_class` (e.g. `"temperature"`, `"moisture"`)
`unit`	string	""	Unit of measurement (e.g. `"°C"`)
`dataType`	int	0	ZCL data type. Required for configuring reporting and if this attribute is writable. Can be omitted if the attribute is not writable and not reported.
`ram`	bool	false	If True, ZHB will create a special container (record) for this attribute in RAM at startup. The received value will be cached in this container, only the last value is stored.
`rp`	bool	false	Configure attribute reporting during interview. Also adds this attribute to web UI "configure reporting" dialog.
`minReport`	int	1	Reporting: minimum interval, s. Can be omitted if `rp` is `false`
`maxReport`	int	3600	Reporting: maximum interval, s. Can be omitted if `rp` is `false`
`change`	int	1	Reporting: reportable change threshold. Can be omitted if `rp` is `false`
`rpChangeMult`	real	0	Multiplier for the web UI "configure reporting" dialog: raw ZCL reportable change = human value × `rpChangeMult` (e.g. `100` for 0.01-unit temperature). Can be omitted if `rp` is `false`
`query`	bool	false	If True, the coordinator will send a request to read this attribute when the hub starts.
`on_normalize`	function	nil	Tells ZHB how to convert raw Zigbee data into usable data, see §5.4

Key	Type	Default	Meaning
`on_serialization`	function	nil	Tells ZHB how to convert data in a container (record) into a text representation, see §5.5
`on_discovery`	function	nil	Allow you to customize/veto discovery for this attribute, see §5.6
`on_mqtt_write`	function	nil	Tells ZHB how to handle `{base}/write/...` MQTT messages, see §5.7

`mqttClass` values:

Value	Class
0	NONE (not exposed to WEB/MQTT)
1	BINARY_SENSOR
2	BUTTON
3	TRIGGER
4	~~EVENT~~ (*Not supported by ZHB dashboard*)
5	~~FAN~~ (*Not supported by ZHB dashboard*)
6	LIGHT
7	NUMBER
8	SELECT
9	SENSOR
10	SWITCH
11	~~TEXT~~ (*Not supported by ZHB dashboard*)
12	~~COVER~~ (*Not supported by ZHB dashboard*)

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5. Callback reference

All callbacks run inside your script's VM, scheduled through the Berry event system. The hub task waits up to ~20 ms for the VM to become available; if the VM is busy longer (e.g. a blocked loop in your script), the **event is dropped** — keep both the callbacks and the rest of the script non-blocking.

`dev` arguments are `ZigbeeDevice` instances, `record` arguments are `ZclAttrRecord` instances (§6). `doc`/`data` are JSON proxy objects supporting `obj["key"] = value` style access.

5.1 on_annonce

Called when an attached device sends a device announce (typically power-on or rejoin). Return value ignored.

5.2 on_intw_stage

Called before interview stages, identified by string `tag`. Return one of:

Return	Meaning
`0` (DONE)	Stage handled by the converter — hub skips its standard logic and go to next stage
`1` (WAIT)	Converter started something async — hub waits, stage will be re-entered
`2` (ERR)	Fail interview on this stage
`3` (ZCN_UNUSED)	Converter does not care — hub runs standard logic (**default choice**)

Stage tags: `req_ep`, `discover_ep`, `get_power_source`, `autobind`, `conf_reporting`, `ias_enroll`, `get_ias_type`, `send_tuya_magic`.

Caveat (same as native): on the **first** interview the converter is matched at the `intw_zcn` stage, so tags for stages ordered *before* it (`req_ep`, `discover_ep`) only fire on re-interview — unless the device was pre-attached with `ZCN.attach()`.

5.3 cmd_config.on_cmd

Called when a ZCL **command** arrives on the cluster (`record.isCmd()` is true; `record.getAttr()` holds the command id). Return the action string to publish (must be one of the `exposes` values for HA to recognize it). Non-string return = not handled.
Important for Tuya commands: `record.asInt()` contains the ID of the Tuya command and `record.getAttr()` its data.

5.4 on_normalize

Called right after the raw ZCL value is parsed into the record, **before** it is stored and serialized. Mutate the record in place:

```
"on_normalize": def (record, dev)
  record.setFloat(record.asInt() / 100.0)
end
```

You can also *redirect* a record to another cluster/attr (`record.setCl()`, `record.setAttr()`, `record.setEp()`) — e.g. unpacking a proprietary struct into standard records. The redirect target attr must exist (declare it with `ram: true`).

5.5 on_serialization

Called when the stored record is converted to JSON for MQTT / web dashboard.
Write into `data`:

```
"on_serialization": def (record, dev, data)
  data["type_sm"] = "report"
  data["val"] = record.asFloat()
end
```

Keys follow the native `zcl_json` convention: `"type_sm"` (usually `"report"`) and `"val"`. If absent, standard serialization for the data type applies.

5.6 on_discovery

Called when generating discovery payload for this attribute. `doc` is the discovery JSON (base payload already filled from `mqttClass`/`mqttSubClass`/`name`/`unit`); `zhbBase` is the MQTT base topic. Add or override keys, e.g. `doc["state_class"] = "measurement"`. In most cases, you only use `doc` if you need to add something (like `min`, `max` and `step` for a slider).

Return `true` to publish, **`false` to veto** discovery of this attribute. Note: with no callback set the attribute is still discovered when `mqttClass != 0`; but if you *do* set a callback, you must return `true` for it to be published.

5.7 on_mqtt_write

Called for MQTT messages on the `{base}/write/...` topic targeting this attribute. `data` is the raw payload string. Convert and send to the device (`dev.sendCmd`, `dev.sendTuyaData`, etc.). Return `true` = handled (standard ZCL write skipped).

5.8 on_mqtt_cmd (cluster level)

Same idea for the `{base}/cmd/...` topic — cluster commands sent from MQTT (e.g. switch toggles). Return `true` = handled.

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6. Objects available in callbacks

6.1 ZigbeeDevice - Berry Zigbee device proxy

Method	Description
`matcher(manuf, model) -> bool`	Exact manuf+model compare
`getName()` / `getIeee()` / `getModel()` / `getManuf()` / `getNwk()`	Identity
`hasName()` / `setName(s)` / `setModel(s)` / `setManuf(s)`	Identity write access (e.g. normalizing Tuya `_TZE200_...` model strings in a `matcher`)
`getPS()` / `setPS(v)`	Power source (`CONST_ZCL_PS.*`)
`getBattery()` / `getLqi()` / `getLastSeen()`	Telemetry
`getIAS()` / `setIAS(v)`	IAS zone type (`CONST_ZCL_IAS.*`)
`isBattery()` / `isAc()` / `isTuya()` / `haveTuyaDP()` / `isInterviewing()` / `isZcnUsed()`	State predicates (`isZcnUsed` = a **native** converter is attached)
`haveEndpoint(ep)` / `addEp(ep)` / `removeEp(ep)`	Endpoint list management (`addEp` creates an empty endpoint — populate it with `addInCluster`/`addOutCluster`)
`hasInCluster(cl)` / `addInCluster(cl [, ep])`	Input cluster list (ep 0 / omitted = first endpoint); duplicate-safe
`hasOutCluster(cl)` / `addOutCluster(cl [, ep])`	Output cluster list, same semantics
`removeCluster(ep, cl)`	Remove a single input cluster from an endpoint ("ignore cluster X" quirks)
`getVal(ep, cl, attr)` / `setVal(ep, cl, attr, value)`	Read / update a stored record value (`setVal` accepts bool/int/real/string/bytes and only updates an **existing** record)
`addRecord(ep, cl, attr)` / `haveRecord(ep, cl, attr)` / `removeRecord(ep, cl, attr)` / `removeAllRecords()`	RAM record management
`queryAllRecords([pauseMs])` / `queryMissingRecords([pauseMs])`	Actively read all / value-less records from the device (**warning**: a non-zero pause blocks the script and the hub for pause × records ms — prefer 0)
`startPooling(intervalSec, ep, cl, attr)` / `stopPooling(ep, cl, attr)`	Periodic attribute polling driven by the hub task
`sendOnOff` / `sendBri` / `sendColor` / `sendColorTemp`	High-level actuator commands
`sendCmd(ep, cl, cmd [, bytes])`	Raw ZCL cluster command
`sendTuyaData(dp, ztype, val)`	Tuya 0xEF00 datapoint write
`sendTuyaQuery()` / `sendTuyaMagic()`	Tuya: query all datapoints / send the "magic" init packet (typical in `on_annonce`)
`readAttr(ep, cl, attr...)`	ZCL Read Attributes request

Method	Description
`writeAttr(ep, cl, attr, dType, bytes)`	ZCL Write Attribute with a raw payload (for custom `on_mqtt_write` handlers)
`confReporting(ep, cl, attr, dType, minReport, maxReport, change)`	ZCL Configure Reporting (for custom `on_intw_stage("conf_reporting")` handling)
`nodeDescReq()` / `simpleDescReq(ep)` / `reqEndpoints()`	Low-level ZDO requests; responses are processed by the interview state machine, so these are mainly useful inside `on_intw_stage`
`bindToHub` / `bindToDevice` / `bindToGroup`	Binding operations
(module-level) `ZHB.await(seq [, timeoutMs]) -> bool` / `ZHB.lastStatus()` / `ZHB.on_response(seq, cb(ok, status) [, timeoutMs]) -> bool`	Wait for the device's response to a previous send (sync / async); the device is resolved from `seq`. **`ZHB.await()` raises inside ZCN callbacks** — they run on the ZHB task; use `ZHB.on_response()` there. See `docs/slzb-os-scripts/docs/modules/zhb.md`

6.2 ZclAttrRecord - Zigbee data container

Getters: `getEp()`, `getCl()`, `getAttr()`, `getStatus()`, `getZtype()` (raw ZCL type), `getSMtype()` (internal storage type, compare against `ZclAttrRecord.TYPE_*` constants: `TYPE_NONE/U32/I32/FLOAT/BUF/STR/BOOL/CMD/CMD_PAYLOAD`).

Predicates: `isCmd()`, `isCmdPayload()`, `isTuya()` (cluster == 0xEF00), `hasPayload()` (type is not `TYPE_NONE`), `matcher(cl, attr [, ep]) -> bool`.

Value access: `asInt()`, `asFloat()`, `asStr()`, `asBytes()`, `asLumiStruct([start])` — parses the Lumi/Aqara proprietary struct (Basic 0xFF01/0xFF02 buffer) into a `{tag_id: int}` map; `getMSB16()` / `getLSB16()` — high/low 16-bit halves of the raw 32-bit value (e.g. packed color X/Y).

Mutation: `setInt(v)`, `setUInt(v)`, `setFloat(v)`, `setBool(v)`, `setStr(v)`, `setBuf(bytes)` (replaces the payload with a copy of a Berry `bytes()` buffer, 1–255 bytes), `setCmd(cmdId [, tuyaCluster])`, `setMSB16(v)` / `setLSB16(v)`, `setEp(v)`, `setCl(v)`, `setAttr(v)`.

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7. ZCNP — native callback presets

The `ZCNP` module exposes ready-made **preset functions** used by built-in converters, so a Berry converter can reference them directly instead of re-implementing the logic:

```
import ZCNP
...
"on_normalize": ZCNP.zcn_norm_i16_divide_100, # the received zigbee value has data type int16
and needs to be divided by 100 to convert it to float
```

```
"on_serialization": ZCNP.zcn_ser_float, # the received value is converted to float, so we convert float to string
"on_discovery": ZCNP.zcn_dis_gen_basic_measurement, # add "measurement" class on discovery
```

Kind	Functions
normalize	`zcn_norm_i16_divide_10/100/1000`, `zcn_norm_u16_divide_10/100/1000`, `zcn_norm_lumi_basic`
serialization	`zcn_ser_float`, `zcn_ser_raw_uint`, `zcn_ser_xy`, `zcn_tuya_ser_switch`, `zcn_ser_tuya_batt_enum`, `zcn_ser_lumi_basic`
discovery	`zcn_dis_gen_basic`, `zcn_dis_gen_basic_measurement`, `zcn_dis_tuya_batt_enum`
mqtt write	`zcn_write_tuya_int`, `zcn_write_tuya_float_int100`, `zcn_write_int16`, `tuya_switch_handler`
cmd	`zcn_cmd_onoff_action`, `tuya_ias_wd_cmd_action`

`zcn_norm_i16_divide_10/100/1000`	divides received two-byte signed int by 10/100/1000 and converts result to **float**. Typically used for temperature sensors, etc.
`zcn_norm_u16_divide_10/100/1000`	divides received two-byte unsigned int by 10/100/1000 and converts result to **float**. Typically used for humidity or voltage sensors, etc
`zcn_norm_lumi_basic`	parses the battery value from the proprietary LUMI structure and sends it to the basic cluster
`zcn_dis_gen_basic`	generates the minimum possible discovery payload
`zcn_dis_gen_basic_measurement`	generates the minimum possible discovery payload and add: {"state_class": "measurement"}
`zcn_dis_tuya_batt_enum`	battery enumeration: high, med, low
`zcn_cmd_onoff_action`	handles standard ZCL ON/OFF commands for cluster 0x0006
`tuya_ias_wd_cmd_action`	
`zcn_write_tuya_int`	sends the received value as **tuya int** type
`zcn_write_tuya_float_int100`	converts the received **float** value to **int** by multiplying by 100 and sends it as **tuya int** type
`zcn_write_int16`	writes a ZCL attribute with int16 data type
`tuya_switch_handler`	converts the received text "ON"/"OFF" text to **bool** (1/0) and sends it as **tuya bool** type

8. ZCN module API

Public functions:

Function	Description
`ZCN.register(converter_map) -> int`	Register a converter from a Berry map (see §4). returns used slot number, raises a error on failure
`ZCN.attach(slot, ieee_str) -> bool`	Attach converter to a paired device (IEEE as hex string, e.g. `"0x00124b00..."`). Clears the device's saved-message cache and (re)creates the converter's RAM records. Raises on: hub not started, bad slot, unknown IEEE.
`ZCN.delete(slot)`	Free the slot: unpins all callbacks, frees all allocations. Automatic when the VM stops

9. Example — SNZB-01P custom button actions(triggers)

```
#META {"start":0}
#ZCN_BUILDER
{"scriptVariableName":"snzb01p_zcn","autostartOnBoot":false,"signatureMode":"model","signature
Model":"SNZB-
01P","signatureManufacturer":"eWeLink","matcherCallback":{"enabled":false,"presetReference":""
,"bodyText":""},"onAnnonce":{"enabled":false,"presetReference":"","bodyText":""},"onIntwStage"
:{"enabled":true,"presetReference":"","bodyText":"if (tag == \"intw_get_power_source\")\n
dev.setPS(3)  # battery\n  return 0\nend\nreturn 3  # ZCN unused - standard
handling"},"attachEnabled":false,"attachIeeeAddress":"","endpointOverrides":[{"endpointNumber"
:1,"clusters":[{"clusterIdText":"0x0006","addMode":0,"bindCluster":false,"onMqttCmd":{"enabled
":false,"presetReference":"","bodyText":""},"commandConfig":{"enabled":true,"exposesList":"btn
_single|btn_double|btn_long","onCmd":{"enabled":true,"presetReference":"","bodyText":"# attr:
0 = long, 1 = double, 2 = single\nvar names = ['btn_long', 'btn_double', 'btn_single']\nvar id
= record.getAttr()\nif (id < 3) return names[id] end\nreturn
\"\""},"exposesOverride":{"enabled":false,"presetReference":"","bodyText":""}},"attributes":[]
}]}]}
import ZCN
```

```
var snzb01p_zcn = {
  "signature": {
    "model": "SNZB-01P",
    "manuf": "eWeLink",
  },
  "on_intw_stage": def(dev, tag)
    if (tag == "intw_get_power_source")
      dev.setPS(3)  # battery
      return 0
    end
    return 3  # ZCN unused - standard handling
  end,
  "overrides_count": 1,
  "overrides": [
    {
      "endpoint": 1,
      "clusterCount": 1,
      "clusters": [
        {
          "id": 0x0006,
          "cmd_config": {
            "exposes": "btn_single|btn_double|btn_long",
            "on_cmd": def(dev, record)
              # attr: 0 = long, 1 = double, 2 = single
              var names = ['btn_long', 'btn_double', 'btn_single']
              var cmd_id = record.getAttr()
              if (cmd_id < 3)
                return names[id]
              end

              return ""
            end,
          },
        },
      ],
    },
  ],
}

var zcn_slot = ZCN.register(snzb01p_zcn)
```

```
ZCN.attach(zcn_slot, "0x00124b0012345678")  # attach to a device manually
```

10. Gotchas

1. **Counts are explicit.** `overrides_count`, `clusterCount`, `attrCount` are read from the map, not derived from list sizes. A count smaller than the list silently drops entries; a count larger than the list reads will crash device.
2. **Attach every boot.** `zcn_be` is not saved to the device DB. No `ZCN.attach()` after reboot (and no fresh interview) = converter silently inactive.
3. `signature` **is mandatory** — registration raises without it. `matcher` must be a function if present.
4. **Callbacks must be fast.**
5. `on_cmd` **needs** `exposes`**.** Without `exposes` or `exposesOverride` on the same cluster, the command path is never taken.
6. `on_discovery` **must return** `true` for the attribute to be discovered — a forgotten return (nil) vetoes it.
7. `ram: true` **for redirect targets and dashboard-only values** — otherwise the record does not exist until the device first reports it (or ever, for synthetic attrs).
8. **Slot exhaustion.** Only `2` Berry converters can exist at once, across all scripts. A crashed-then-restarted script frees and re-takes its slots automatically, but a script that registers in a loop will run out.
9. `ZCN.attach` **requires a running hub and a paired device** — it raises `"enable zHub first"` / `"wrong device ieee"` otherwise. If your script autostarts before the hub is up, wait via `ZHB.waitForStart()` first.
10. **Multiple matching converters:** Not recommended. Converters are meant to be unique.
11. **Berry converters are much slower than native ones!** Berry ZCN intended for rapid prototyping, not for continuous use as it will slow down the system.

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