

Reference Calibration Card Specification for **dvi3v**
project
v3.9.2.208

Peter Felecan
with Claude (Anthropic AI), model Sonnet 5

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1 Introduction

1.1 Purpose

This document covers the calibration reference used to validate the `dvi3v` system’s dimensional accuracy and detection capabilities: the ISO 12233 chart currently in use, and a custom card design intended to eventually replace it.

1.2 Use Cases

- Baseline accuracy validation
- System calibration
- Regression testing after software/hardware changes
- Comparison between different camera devices
- Educational demonstrations

2 Currently in Use: ISO 12233 Standard Chart

The calibration reference actually in use is the **ISO 12233:2014** standard resolution test chart (`TestInstrumentation/ReferenceCard/ISO_12233-reschart.svg`):

- Widely available online (search "ISO 12233 chart PDF")
- Contains resolution targets and geometric patterns
- Industry-standard for camera calibration
- Can be printed on A4
- Has known dimensions for specific chart versions

It was adopted as a practical substitute for the custom card specified below, which has not yet been built. See *Custom Card Design (Specified, Not Yet Built)* for the card intended to eventually replace it, and FutureResearch.org for the plan to build and validate it.

3 Custom Card Design (Specified, Not Yet Built)

Status: **Designed here; no ReferenceCard.scad, printed card, or validation run exists yet** (`TestResults/Baseline/ReferenceCard/` is empty). The specification below is a target design, not a description of something in use — see the section above for what *is* currently used.

Once built and validated, this design is intended to improve on the ISO chart for dvi3v's specific purpose:

- Known exact dimensions, chosen for this project (not inherited from a chart designed for camera resolution testing)
- Black/white high contrast throughout, no grayscale complexity beyond the deliberate step-wedge target
- Simpler to validate against caliper measurements

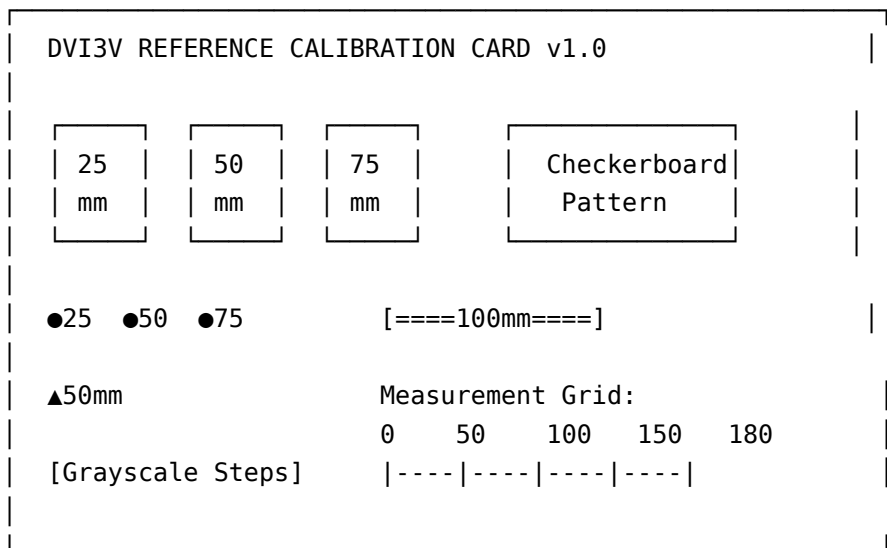
3.1 Physical Dimensions

- **Total size:** 180mm × 120mm (fits comfortably on A4)
- **Material:** Matte white cardstock (200-250 gsm)
- **Thickness:** 0.3-0.4mm (rigid but printable)
- **Surface:** Non-reflective, smooth matte finish

3.2 Layout Design

3.2.1 Overall Structure

The card contains multiple test patterns arranged in a grid:



3.2.2 Component Details

3.2.2.1 1. Square Targets (Top Row)

- Three solid black squares
- Sizes: 25mm, 50mm, 75mm (precise dimensions)
- Spacing: 10mm between squares
- Purpose: Baseline dimensional accuracy
- Position: Top-left quadrant

3.2.2.2 2. Circular Targets (Middle Row)

- Three solid black circles
- Diameters: 25mm, 50mm, 75mm
- Spacing: 10mm between centers
- Purpose: Circular shape accuracy, roundness testing
- Position: Middle-left area

3.2.2.3 3. Linear Scale (Horizontal)

- Length: 100mm (precisely measured)
- Tick marks at: 0, 25, 50, 75, 100mm
- Major ticks: 10mm intervals
- Minor ticks: 5mm intervals
- Line width: 1mm (thick enough to detect reliably)
- Purpose: Linear measurement validation
- Position: Center-right

3.2.2.4 4. Checkerboard Pattern

- Grid: 8×8 squares
- Each square: 10mm × 10mm
- Total: 80mm × 80mm
- Alternating black/white
- Purpose: Edge detection quality, alignment testing
- Position: Top-right quadrant

3.2.2.5 5. Grayscale Step Wedge

- 10 steps from white to black
- Each step: 15mm × 15mm
- Grayscale values: 0%, 10%, 20%, ..., 90%, 100%
- Purpose: Threshold calibration
- Position: Bottom-left

3.2.2.6 6. Measurement Grid

- Horizontal ruler: 0-180mm marked every 10mm
- Vertical ruler: 0-120mm marked every 10mm
- Purpose: Overall dimensional reference
- Position: Right and bottom edges

3.2.2.7 7. Corner Registration Marks

- Four corner marks (crosshairs)
- Each: 5mm × 5mm
- Precisely positioned at card corners
- Purpose: Alignment and perspective detection
- Position: All four corners

3.2.2.8 8. Version and Date

- Text: "dvi3v Reference Card v1.0"
- Date: "Printed: YYYY-MM-DD"
- Purpose: Traceability
- Position: Top center

3.3 Printing Specifications

3.3.1 Print Method

Option 1 (Recommended): **Professional printing**

- Laser printer on cardstock
- 1200 DPI minimum resolution
- True black toner (not grayscale composite)
- Ensures dimensional accuracy

Option 2: **High-quality inkjet**

- Photo-quality inkjet on matte cardstock
- 2400 DPI minimum
- Pigment-based black ink (not dye)
- Allow to dry completely (24h)

3.3.2 Color Settings

- Print mode: Black and white (not grayscale rendering)
- Black squares/circles: 100% K (key/black)
- Grayscale wedge: Precise halftone percentages
- No color management profiles that alter dimensions

3.3.3 Scaling

Critical: Print at 100% scale, NO scaling

- Disable "Fit to page"
- Disable "Shrink oversized pages"
- Set margins to minimum
- Verify with ruler before use

3.4 Validation Before Use

3.4.1 Physical Measurement

Before using the reference card, verify dimensions with calipers:

Feature	Nominal	Tolerance	Verify With
25mm square side	25mm	$\pm 0.2\text{mm}$	Calipers
50mm square side	50mm	$\pm 0.2\text{mm}$	Calipers
75mm square side	75mm	$\pm 0.2\text{mm}$	Calipers
100mm scale	100mm	$\pm 0.1\text{mm}$	Precision
Card width	180mm	$\pm 0.5\text{mm}$	Ruler
Card height	120mm	$\pm 0.5\text{mm}$	Ruler

3.4.2 Acceptance Criteria

- All measurements within tolerance $\rightarrow$ Card accepted
- Any measurement outside tolerance $\rightarrow$ Reprint required
- Document actual measurements for traceability

3.5 OpenSCAD Model for 3D Printed Version

For precise reference, the calibration pattern could also be created as a thin 3D printed object (not yet built):

```
// ReferenceCard.scad - 3D printable calibration card
// Print in black PLA, 0.2mm layers, matte finish

cardThickness = 0.8; // mm - thin but rigid

module ReferenceCard()
{
    difference()
    {
        // Base card (white if using white PLA)
        cube([180, 120, cardThickness]);

        // Black features are recessed 0.4mm (half thickness)
        translate([0, 0, cardThickness - 0.4])
        {
            // 25mm square
            translate([15, 90, 0])
                cube([25, 25, 0.5]);

            // 50mm square
            translate([50, 85, 0])
                cube([50, 50, 0.5]);

            // 75mm square
            translate([110, 80, 0])
                cube([75, 75, 0.5]);

            // 25mm circle
            translate([27.5, 50, 0])
                cylinder(d=25, h=0.5, $fn=100);

            // 50mm circle
            translate([75, 50, 0])
                cylinder(d=50, h=0.5, $fn=100);

            // 75mm circle
            translate([147.5, 50, 0])
                cylinder(d=75, h=0.5, $fn=100);
        }
    }
}
```

```
// 100mm ruler
translate([40, 30, 0])
{
    for(i=[0:10])
    {
        translate([i*10, 0, 0])
            cube([1, (i%5==0) ? 10 : 5, 0.5]);
    }
}

// Checkerboard (simplified)
for(x=[0:7], y=[0:7])
{
    if((x+y)%2 == 0)
    {
        translate([140 + x*10, 80 + y*10, 0])
            cube([10, 10, 0.5]);
    }
}
}

ReferenceCard();
```

4 Usage Protocol

Applies to whichever reference target is in use (currently the ISO 12233 chart; the custom card once built) — "reference card" and "features" below mean whichever one is being validated.

4.1 Setup

1. Place reference card on white A4 paper
2. Ensure card is flat and parallel to camera
3. Card should be centered on A4
4. Lighting should be uniform (no shadows on card)

4.2 Capture

1. Use jig with standard setup

2. Take multiple photos (3-5 captures)
3. Use consistent camera settings

4.3 Validation

1. Process all captures through `dvi3v`
2. Extract SVG for each feature (squares, circles, ruler)
3. Measure SVG dimensions
4. Compare to known physical dimensions
5. Calculate error percentage
6. Average across all captures

4.4 Expected Results

- Dimensional error: $< 1\%$ for all features
- Consistency: Standard deviation $< 0.5\text{mm}$ across captures
- Detection rate: 100% for all features

5 Test Instrumentation Directory

The reference materials live in `TestInstrumentation/ReferenceCard/`. Currently present:

- `ISO_12233-reschart.svg` — the chart actually in use (see *Currently in Use* above)

Once the custom card design is built (see *Custom Card Design* above and `FutureResearch.org`), this directory is where its artifacts belong too:

- `ReferenceCard.scad` (OpenSCAD model)
- `ReferenceCard.svg` (printable vector template)
- `ReferenceCard.pdf` (ready-to-print version)
- `ValidationMeasurements.org` (actual measured dimensions)

6 Conclusion

A reliable, repeatable calibration reference is essential for validating `dvi3v`'s accuracy and establishing baseline performance metrics. The ISO 12233 chart serves this purpose today; the custom card specified above is intended to eventually improve on it with dimensions and patterns chosen specifically for this project, once built and validated.