Load Cell

Load cells measure force/weight to detect object presence, evaluate structural loading, or monitor mechanical stress. The system supports dual load cell configuration.

Hardware Specifications

Parameter	Value
Sensor Count	2 (independent)
Interface	Analog ADC
Measurement	Force (Newtons) / Mass (grams)
Update Rate	Configurable

Data Structure

```
typedef struct {
    // Raw Reading
    int32_t raw_counts;                // ADC value from sensor

    // Converted Measurements
    float force_newtons;               // Force in Newtons (N)
    float mass_grams;                  // Equivalent mass in grams (g)

    // Calibration Parameters
    float scale_newtons_per_count;     // Conversion factor (N/count)
    int32_t tare_offset_counts;        // Zero-load ADC offset

    // Status
    bool is_calibrated;                // Calibration valid flag
} load_cell_data_t;
```

Initialization

Initialize Load Cells

```
load_cell_data_t load_cell_data[2];  // Support 2 sensors

for (size_t i = 0; i < 2; i++) {
    load_cell_sensor_init(&load_cell_data[i]);
}
```

Poll Load Cell Sensor

```
result_t lc_result = poll_load_cell_sensor(&load_cell_data[0]);

if (lc_result == RESULT_OK) {
    float force = load_cell_data[0].force_newtons;
    float mass = load_cell_data[0].mass_grams;
    int32_t raw = load_cell_data[0].raw_counts;
}
```

Data Access Functions

```
// Get force in Newtons
result_t load_cell_get_force_newtons(
    const load_cell_data_t *data,
    float *force_newtons
);

// Get mass in grams (estimated)
result_t load_cell_get_mass_grams(
    const load_cell_data_t *data,
    float *mass_grams
);

// Get raw ADC counts
result_t load_cell_get_raw_counts(
    const load_cell_data_t *data,
    int32_t *raw_counts
);
```

```
// Get calibration parameters
result_t load_cell_get_calibration(
    const load_cell_data_t *data,
    float *scale_newtons_per_count,
    int32_t *tare_offset_counts
);

// Verify sensor validity
result_t load_cell_sensor_is_valid(
    const load_cell_data_t *data,
    bool *is_valid
);
```

Calibration Procedure

Two-Step Calibration

Step 1: Tare (Zero Load)

```
1. Remove all load from sensor
2. Measure ADC value: ADC_zero
3. Set tare_offset_counts = ADC_zero
```

Step 2: Span (Known Weight)

```
1. Place known weight on sensor
2. Measure ADC value: ADC_loaded
3. Know reference force: F_ref (Newtons)

4. Calculate scale:
   scale = (F_ref - 0.0) / (ADC_loaded - ADC_zero)

5. Set scale_newtons_per_count = scale
```

Measurement Formulas

```
// Raw force calculation
Force = (raw_counts - tare_offset_counts) × scale_newtons_per_count

// Mass conversion (approximate)
Mass_grams = (Force_newtons / 9.81) × 1000
           ≈ Force_newtons × 102.04
```

Dual Sensor Management

Configuration Example

```
// Initialize both sensors
for (size_t i = 0; i < 2; i++) {
    load_cell_sensor_init(&load_cell_data[i]);
}

// Poll both in sequence
poll_load_cell_sensor(&load_cell_data[0]);
poll_load_cell_sensor(&load_cell_data[1]);

// Access by index
float load_0 = load_cell_data[0].force_newtons;
float load_1 = load_cell_data[1].force_newtons;
```

Protobuf Message Format

```
message SensorBoardLoadCellInfo {
    uint32 sensor_index;         // 0 or 1
    float force_newtons;
    float mass_grams;
    SensorState state;
    LoadCellErrorCode error_code;
}
```

Unit Conversions

From	To	Factor
Newtons	kilograms-force (kgf)	÷ 9.81
Newtons	pounds-force (lbf)	÷ 4.448
grams	kilograms	÷ 1000

Manual Unit Conversion Example

```
// Convert to pounds-force
float force_lbf = load_cell_data[0].force_newtons / 4.448f;

// Convert to kilograms
float mass_kg = load_cell_data[0].mass_grams / 1000.0f;
```

Typical Specifications

Load Cell Type	Max Load	Accuracy
Strain gauge (±50N)	50N	±0.1%
Load cell (±100N)	100N	±0.05%
Heavy duty (±1000N)	1000N	±0.1%

Integration Notes

- Supports up to 2 independent load cell sensors
- Hardware-specific ADC implementation
- Force conversion via linear scaling model
- Tare offset corrects for sensor mechanical zero
- Real-time monitoring of structural loads
- Each sensor maintains separate calibration
- Independent error reporting per sensor

Revision #3
Created 2026-04-14 15:50:27 UTC by Shishir Nambiar
Updated 2026-04-14 17:17:20 UTC by Shishir Nambiar