GF-CODE

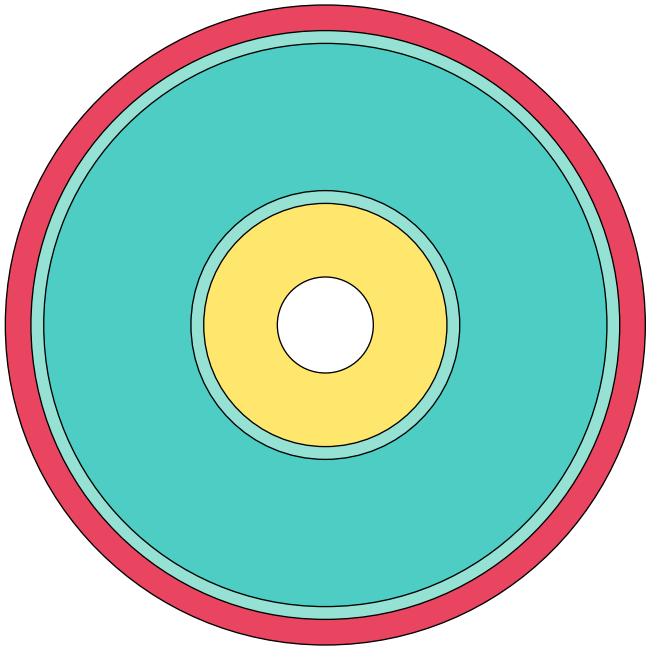
Complete Encoding Guide

Mark Anatomy • Encoding Architecture • Data Types
Reading Order • Examples • Glossary

"Data in Motion"

MARK ANATOMY

The complete GF-Code mark structure from outside to inside



OUTER RING

OUTER QUIET ZONE

SPOKE FIELD

INNER QUIET ZONE

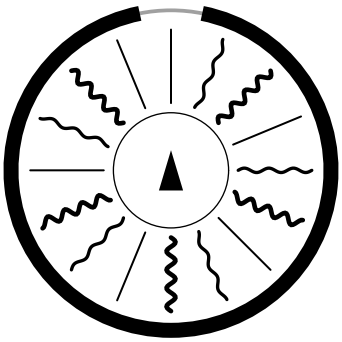
HUB

ZONE SPECIFICATIONS

Zone	Radius %	Purpose	Encodes?
Outer Ring	92-100%	Detection, format data	Yes — format header
Outer Quiet	88-92%	Contrast separation	No
Spoke Field	42-88%	Primary payload	Yes — data
Inner Quiet	38-42%	Contrast separation	No
Hub	0-38%	Index, optional format	Optional — extended
Index Arrow	Center	Rotation reference (12 o'clock)	No

COMPLETE MARK EXAMPLE

- Black outer ring with notch at 12 o'clock
- Gray witness line (always present)
- 16 spokes with waveform encoding
- White hub with black arrow index
- Arrow points UP (0° reference)



ENCODING LAYERS

Three-layer encoding architecture — read in order

LAYER 1: OUTER RING — Format Header

Read FIRST. Tells scanner how to interpret everything else.

Field	Bits	Purpose	Values
Sync	2	Confirms GF-Code	Always 11
Version	3	Spec version	0-7
Size Tier	2	Mark size category	0=Micro, 1=Small, 2=Std, 3=Large
Spoke Count	2	Number of spokes	0=8, 1=12, 2=16, 3=20
Color Mode	2	Encoding color depth	0=Mono, 1=Gray, 2=Chroma5, 3=Chroma20
Data Type	4	Payload format	16 types (see Data Types)
ECC Level	2	Error correction	0=None, 1=Low, 2=Med, 3=High
Checksum	7	Header validation	CRC-7 of fields above
TOTAL	**24**		**Fits 24-segment ring**

LAYER 2: HUB WEDGES — Extended Format (Optional)

Read SECOND. Only on marks >15mm. Additional metadata or overflow.

- 6 Wedges × 3 Bands = 18 cells → ~28 bits (grayscale) / ~42 bits (chromatic)
- 8 Wedges × 2 Bands = 16 cells → ~25 bits (grayscale) / ~37 bits (chromatic)
- Can encode: payload length, encryption flag, app ID, extended ECC

LAYER 3: SPOKES — Payload Data

Read THIRD. The actual content. Decoded using format from Layer 1.

Bits per Spoke:

Property	Levels	Bits
Amplitude	3 (None/Low/High)	1.58
Frequency	3 (2/3/4 waves)	1.58
Gauge	3 (Thin/Med/Thick)	1.58
Phase	2 (Aligned/Offset)	1.00
SUBTOTAL (Mono)		**~5.75**
+ Grayscale	3 levels	+1.58 → ~7.3
+ Chromatic	5 levels	+2.32 → ~8.0

TOTAL CAPACITY BY CONFIGURATION

Config	Spokes	Bits/Spoke	Raw Bits	After ECC	Net Bytes
Micro Mono	8	5.75	46	~37	4 B
Micro Color	8	8	64	~51	6 B
Small Mono	12	5.75	69	~55	6 B
Small Color	12	8	96	~77	9 B
Standard Mono	16	5.75	92	~74	9 B
Standard Color	16	8	128	~102	12 B
Large Mono	20	5.75	115	~92	11 B
Large Color	20	8	160	~128	16 B

READING ORDER

How the scanner decodes a GF-Code mark

1 **DETECT MARK**
Find circular outer boundary in camera frame

2 **FIND INDEX**
Locate notch at 12 o'clock (or arrow in hub)

3 **ESTABLISH 0°**
Index position = 0° reference for all encoding

4 **READ OUTER RING**
Decode format header clockwise from 0°

5 **VALIDATE HEADER**
Check CRC — if fail, retry or abort

6 **READ HUB (if present)**
Decode wedge cells for extended format

7 **READ SPOKES**
Decode payload starting at Spoke 0 (first CW from index)

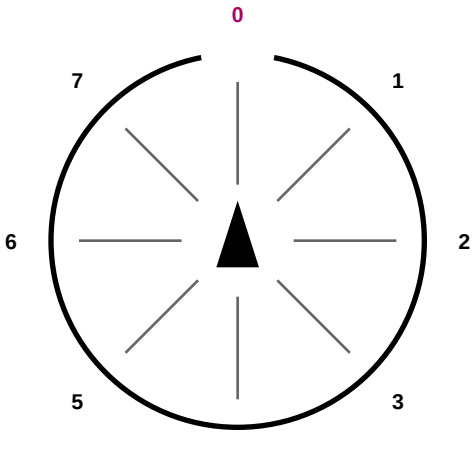
8 **APPLY ECC**
Error correction based on ECC level from header

9 **PARSE DATA**
Interpret payload according to Data Type from header

10 **RETURN RESULT**
Output decoded data to application

SPOKE NUMBERING

Clockwise from index



Spoke 0 = first clockwise from index

Reading proceeds: 0 → 1 → 2 → ... → N

DATA TYPES

Supported payload formats — selected via Data Type field in header

ID	Type	Description	Encoding	Min Size
0x0	RAW	Raw binary bytes	Direct bytes	1 B
0x1	URL	Web URL	Prefix compression + ASCII	3 B
0x2	UUID	Unique identifier	Raw 16 bytes	16 B
0x3	NUMERIC	Numeric ID	Variable int (3.3 bits/digit)	1 B
0x4	ALPHA	Alphanumeric code	Base36 (5.17 bits/char)	1 B
0x5	TEXT	Short text	UTF-8 compressed	1 B
0x6	PHONE	Phone number	E.164 format	7 B
0x7	GEO	GPS coordinates	Fixed-point lat/long	8 B
0x8	WIFI	WiFi credentials	SSID + password	4 B
0x9	VCARD	Contact card	Structured fields	10 B
0xA	POINTER	Database lookup	Server-side ID	4 B
0xB	CRYPTO	Crypto address	Coin ID + address	22 B
0xC-E	RESERVED	Future use	—	—
0xF	EXTENDED	Extended type	Next byte = subtype	2 B

URL PREFIX COMPRESSION

First byte of URL payload indicates prefix:

0x00	(none)	—
0x01	http://	Saves 7 bytes
0x02	https://	Saves 8 bytes
0x03	https://www.	Saves 12 bytes
0x04	https://gf.co/	Saves 14 bytes

Example: https://gf.co/abc → 0x04 + 'abc' = 4 bytes instead of 18

ERROR CORRECTION LEVELS

Reed-Solomon ECC (same algorithm as QR codes):

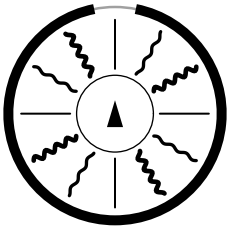
Level	Code	Overhead	Recovery	Best For
None	00	0%	0%	Maximum capacity, pristine conditions
Low	01	10%	~7%	Clean environments
Medium	10	20%	~15%	Standard use (recommended)
High	11	30%	~25%	Harsh environments, wear expected

ENCODING EXAMPLES

How different data types map to marks

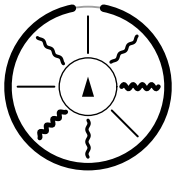
EXAMPLE 1: Short URL

Input: https://gf.co/p/12345
Encoded: 0x04 (prefix) + 'p/12345' = 8 bytes
Config: 12 spokes, chromatic (9 bytes capacity) — fits in Small Color mark



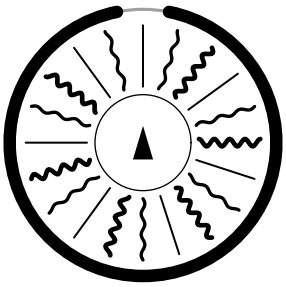
EXAMPLE 2: Numeric Product ID

Input: 8675309
Encoded: Variable int = 3 bytes
Config: 8 spokes, mono (4 bytes capacity) — fits in Micro Mono mark



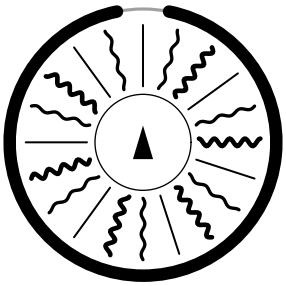
EXAMPLE 3: UUID (Product Authentication)

Input: f47ac10b-58cc-4372-a567-0e02b2c3d479
Encoded: Raw 16 bytes (no dashes)
Config: 20 spokes, chromatic (16 bytes capacity) — requires Large Color mark



EXAMPLE 4: WiFi Credentials

Input: SSID='GuestNet', Password='welcome1'
Encoded: 1 byte (SSID len) + 'GuestNet' + 1 byte (pass len) + 'welcome1' = 18 bytes
Config: 20 spokes + hub wedges, chromatic — requires Large Color with Hub



SIZE SELECTION GUIDE

Data Size	Recommended Config	Physical Size
1-4 bytes	Micro Mono (8 spokes)	6-10mm
5-6 bytes	Micro Color or Small Mono	8-12mm
7-9 bytes	Small Color or Std Mono	12-16mm
10-12 bytes	Standard Color	16-20mm
13-16 bytes	Large Color	20-25mm
17-22 bytes	Large Color + Hub	25-30mm

OUTER RING OPTIONS

Visual encoding styles for the format header ring

LINE WEIGHTS (relative to base ring width)

Element	Width	Color	Purpose
Witness	25%	Gray (#A0A0A0)	Always present — detection baseline
Thin	75%	Black	Used in Gauge and Ternary encoding
Thick	125%	Black	Solid segments in all encoding types

ENCODING TYPES

NOTCH	1 bit	Solid ring with gap at 12 o'clock (index reinforcement)
BINARY	1 bit/seg	Thick segments or gaps (witness shows through)
GAUGE	1 bit/seg	Thick or thin segments (no gaps)
TERNARY	~1.58 bits/seg	Thick, thin, or gap (maximum density)

SEGMENT COUNTS BY SIZE

Micro (6-10mm)	8 segments	8 bits (Binary)
Small (12-16mm)	12-16 segments	12-16 bits
Standard (16-25mm)	24 segments	24 bits
Large (25mm+)	24-32 segments	24-32 bits

GLOSSARY

Official terminology for GF-Code

Amplitude
Lateral displacement of spoke waveform from center line. Levels:

Band
Concentric ring within Hub wedge structure. Creates cells at wedge ×

Cell
Single encoding unit at wedge/band intersection in Hub. Holds one

Checksum
Validation bits in format header. CRC-7 of preceding fields.

Chromatic
Color encoding mode using 5 or 20 distinct hues.

ECC
Error Correction Code. Reed-Solomon redundancy for damage recovery.

Format Header
Metadata in outer ring telling scanner how to decode the mark.

Frequency
Number of wave cycles along spoke length. Levels: 2, 3, or 4 waves.

Gauge
Line thickness of spoke stroke. Levels: Thin (75%), Medium (100%),

Grayscale
Color mode using Black, Gray (#A0A0A0), and White.

Groove
Complete GF-Code mark. The official term for the symbol.

Hub
Central region containing index arrow and optional wedge encoding.

Index
Black arrow pointing to 12 o'clock. Establishes 0° rotation reference.

Notch
Gap in outer ring at 12 o'clock. Reinforces index, can encode 1 bit.

Open Mode
Security mode where payload is the actual data. Freely copyable.

Outer Ring
Outermost band containing format header. First thing scanner reads.

Payload
User data encoded in spokes. The actual content of the mark.

Phase
Starting position of waveform. Levels: Aligned (0°), Offset (90°).

Quiet Zone
Blank buffer rings providing contrast. Inner and outer.

Secured Mode
Security mode where payload is a server lookup ID. Copy-protected.

Segment
Arc portion of outer ring. Encodes one unit of format data.

Spoke
Radial line from hub to outer ring. Primary data carrier.

Spoke Field
Annular region containing all data spokes.

Tier
Size category. Micro (6-10mm), Small (12-16mm), Standard

Wedge
Pie-slice sector in Hub. Creates cells when combined with bands.

Witness Line
Thin gray circle (25%) always present. Detection baseline for

SECURITY MODES

Open vs. Secured — determined by Security Mode bit in header

OPEN MODE (Security = 0)

Payload IS the data. What you encode is what you get.

Characteristics:

- Data stored directly in mark
- No server connection required
- Fully offline capable
- Copying the mark copies the data
- No copy protection

Best For:

- URLs and links
- WiFi credentials
- Contact cards
- Public information
- Situations where copying is acceptable

SECURED MODE (Security = 1)

Payload is a POINTER. Server validates authenticity.

Characteristics:

- Mark contains lookup ID (UUID or short code)
- Scanner contacts validation server
- Server confirms authenticity, returns real data
- Copies detected (same ID scanned multiple times/locations)
- Marks can be revoked server-side

Best For:

- Product authentication
- Anti-counterfeiting
- Luxury goods verification
- Event tickets (prevent duplication)
- Anything where copying must be prevented

SECURED MODE FLOW

1. Mark created with unique ID → ID registered in server database
2. User scans mark → App extracts ID from payload
3. App contacts server → 'Is ID abc123 valid?'
4. Server checks → Valid? First scan? Location? Time?
5. Server responds → 'Yes, authentic' + product details OR 'Suspicious/Revoked'
6. App displays result to user

QUICK REFERENCE

Everything on one page

MARK STRUCTURE (outside → inside)

Outer Ring (format) → Outer Quiet → Spoke Field (data) → Inner Quiet → Hub (index + optional)

ENCODING LAYERS

1. Outer Ring: Format header (24 bits) — version, spokes, color, type, ECC, checksum
2. Hub Wedges: Extended format (optional, 25-42 bits)
3. Spokes: Payload data (5.75-8 bits per spoke)

SPOKE PROPERTIES

Amplitude: None/Low/High (3) | Frequency: 2/3/4 waves (3) | Gauge: Thin/Med/Thick (3) | Phase: 0°/90° (2)
Mono: ~5.75 bits/spoke | +Grayscale: ~7.3 bits | +Chromatic: ~8 bits

OUTER RING LINE WEIGHTS

Witness: 25% (gray) | Thin: 75% (black) | Thick: 125% (black)

CAPACITY (after ECC)

Micro (8 spokes): 4-6 B | Small (12): 6-9 B | Standard (16): 9-12 B | Large (20): 11-16 B | +Hub: +3-7 B

COMMON DATA TYPES

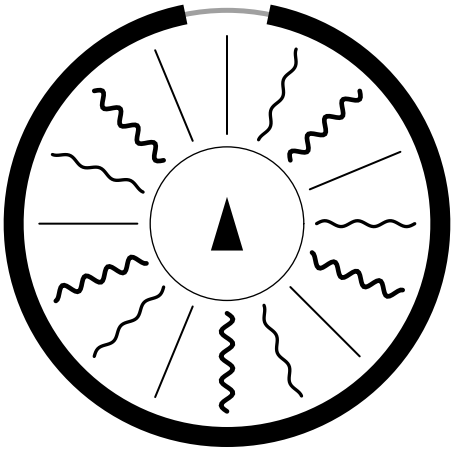
0x1 URL | 0x2 UUID | 0x3 Numeric | 0x4 Alphanumeric | 0x5 Text | 0x6 Phone | 0x8 WiFi | 0xA Pointer

READING ORDER

Detect circle → Find index (12 o'clock) → Read outer ring CW → Validate checksum → Read hub → Read spokes CW

SECURITY MODES

Open (0): Data in mark, copyable | Secured (1): Pointer to server, copy-protected



GROOVE FIDELITY

"Data in Motion"