Leuze electronic

the sensor people

SMART
SENSOR
BUSINESS

BAR CODE DETECTION

White Paper

www.leuzeusa.com

Chapter 1

WHAT IS A 1D BAR CODE AND WHAT IS IMPORTANT – THE FUNDAMENTALS OF A 1D BAR CODE.

Welcome to Leuze electronic bar code detection 101. This is a collection of chapters to provide you more information about technologies and products to make your life easier and less complicated.

We all know bar codes are used in many industries from managing Material flow/ Materials handling companies, Electronics manufacturers, Automobile manufacturers and Automotive suppliers, Wholesale and Retail with consumer items including both food and non-food packaging, Aviation, Order processing, Post distribution and In-house post, Public authorities, Logistics companies and more.

In lab automation there are specific applications including the tracking of **blood samples and sample tubes. In medical applications, clinical logistics, packaging and pharmaceuticals** for tracking of product descriptions and more.

So why use a bar code and why are they so popular?

Bar codes provide a high degree of data security, with high first read rate probabilities, automatic bar code identification results with the lowest error rate, high productivity and throughput (quantity) and highly reliable reading systems performed inexpensively.

What should be important to you?

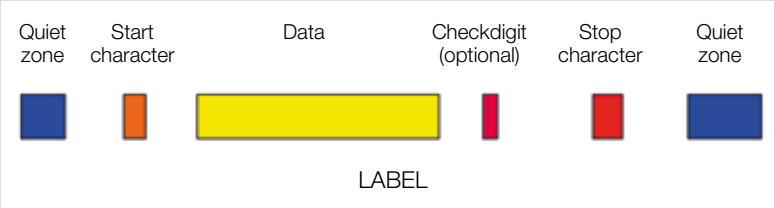
The bar code results can be further processed perfectly in automatic systems, the bar code information can be read on the label with the additional text line, low-cost label material can be purchased like printers and readers, and simple training should be needed for operators and users. These systems should be able to be used in almost all environments.

What are the fundamentals needed to accomplish these tasks?

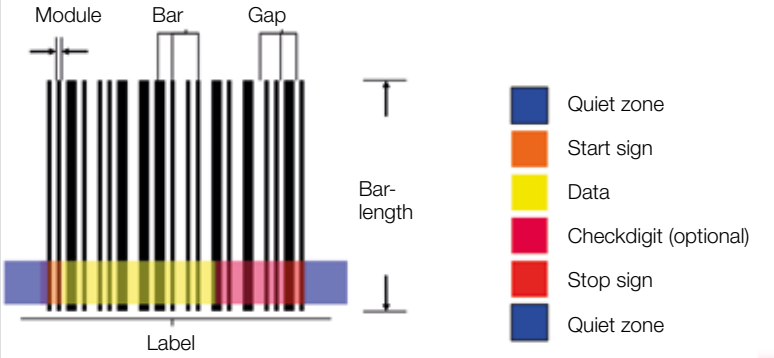
Bar codes need to include at least the following:

- **Quiet zone (B_Z)** = the light area before the start character and after the stop character of a bar code. The quiet zone (min. 10 x Module) is needed in order to indicate the start of the bar code to the scanner.
- **Module Size (M)** = the narrowest bar or gap in a bar code
- **Broad bar or gap (Z_B)** = Broad bars or gaps are always a multiple of the module. Module x Ratio = Z_B (Normal Ratio 1:2.5)
- **Length of the bar code (L)** = the length of the bar code including start/stop character (in mm). Depending on definition, the quiet zone must be added or not.
- **Length of a bar (in mm) (S_L)** =

The bar code structure consists in general of following items. Any 1D bar code structure starts with the quiet zone followed by the start character. To secure a correct decoding of a bar code the quiet zone is essential and must be without any disturbing markings. It is recommended to have a quiet zone of at least 10 times the module width, with a minimum of 2.5 mm.



The start character is unique and together with the stop character the reading orientation can be defined as well as the code type. Start and stop character are different from each other. An exception to this rule is the EAN-code which has the same start and stop character. Some bar codes do not have a start and stop character, e.g. the pharma code. Optionally bar codes can have a checkdigit, which increases to the correct decoding of the bar code. The checkdigit is then compared to the calculated sum of the scanner and the result will create an output if the read and calculated checkdigit are equal.



Commonly used 1D bar code types are:

Code 2/5 Interleaved (most popular mumeric code in the industry)		**Advantages**	very high density at low space self checking
		Disadvantages	requires precise print tolerantes (tolerance ± 10%) simple decoding algorithm ➔ a control character or a fixed length is recommended
Code 39 (first alphanumeric code; widely used in wholesaling and in industry)		**Advantages**	self checking secure and accurate coding alphanumeric characters
		Disadvantages	low information density low tolerances (± 10%)
Code EAN 128 (standardised as a logistics code for retail applications))		**Advantages**	self checking high information density secure and accurate coding alphanumeric ASCII cgaracter set
		Disadvantages	low tolerances (four-width code) consecutive code 3 data sets necessary in order to code ASCII table

The history of bar codes:

In 1948 **Bernard Silver**, a graduate student at **Drexel Institute of Technology** in **Philadelphia**, Pennsylvania, US overheard the president of the local food chain, **Food Fair**, asking one of the deans to research a system to automatically read product information during checkout.[1] Silver told his friend **Norman Joseph Woodland** about the request, and they started working on a variety of systems. Their first working system used **ultraviolet** ink, but the ink faded too easily and was rather expensive.[2][3]

Convinced that the system was workable with further development, Woodland left Drexel, moved into his father's apartment in Florida, and continued working on the system. His next inspiration came from **morse code**, and he formed his first bar code from sand on the beach. "I just extended the dots and dashes downwards and made narrow lines and wide lines out of them."[2] To read them, he adapted technology from optical soundtracks in movies, using a 500-watt incandescent light bulb shining through the paper onto an RCA935 **photomultiplier tube** (from a movie projector) on the far side. He later decided that the system would work better if it were printed as a circle instead of a line, allowing it to be scanned in any direction.

On 20 October 1949 Woodland and Silver filed a patent application for "Classifying Apparatus and Method", in which they described both the linear and **bullseye** printing patterns, as well as the mechanical and electronic systems needed to read the code. The patent was issued on 7 October 1952 as US Patent 2,612,994. In 1951, Woodland moved to **IBM** and continually tried to interest IBM in developing the system. The company eventually commissioned a report on the idea, which concluded that it was both feasible and interesting, but that processing the resulting information would require equipment that was some time off in the future.

IBM offered to buy the patent, but its offer was not high enough. **Philco** purchased their patent in 1962 and then sold it to **RCA** sometime later.[2]

Currently bar codes are used in many different applications and forms and are commonly and worldwide used. Some companies are using uniquly designed bar codes to increase the brand recognition.

References:

1. *Fishman, Charles (1 August 2001). "The Killer App – Bar None". American Way. Archived from the original on 12 January 2010. Retrieved 2010-04-19.*
2. *Seideman, Tony, „Barcodes Sweep the World", Wonders of Modern Technology*
3. *Seideman, Tony (Spring 1993). „Barcodes Sweep the World". AccuGraphiX / History of Bar Codes. Archived from the original on 5 November 2016. Retrieved 5 November 2016. Article published in Wonders of Modern Technology, Spring 1993.*

Switching Sensors
Optical Sensors
Ultrasonic Sensors
Fiber Optic Sensors
Inductive Switches
Forked Sensors
Light Curtains
Special Sensors

Measuring Sensors
Distance Sensors
Sensors for Positioning
3D Sensors
Light Curtains
Forked Sensors

Products for Safety at Work
Optoelectronic Safety Sensors
Safe Locking Devices, Switches and Proximity Sensors
Safe Control Components
Machine Safety Services

Identification
Bar Code Identification
2D-Code Identification
RF Identification

Data Transmission/
Control Components
MA Modular Connection Units
Data Transmission
Safe Control Components

Industrial Image Processing
Light-Section Sensors
Smart Camera

Leuze electronic, Inc
55395 Lyon Industrial Drive
New Hudson, MI 48165 / USA
Phone (248) 486-4466
Fax (248) 486-6699
www.leuzeusa.com

us 01-2016/12
Subject to modifications and errors

Leuze electronic

the sensor people

SMART
SENSOR
BUSINESS

BAR CODE DETECTION

White Paper

www.leuzeusa.com

Chapter 2

READING FIELDS

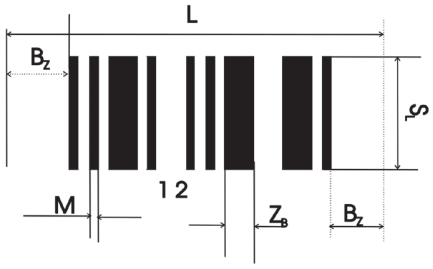
Welcome to Leuze electronic bar code detection 101. This is a collection of chapters to provide you more information about technologies and products to make your life easier and less complicated.

Reading Fields – what are they and how would a Lab Automation professional use these?

A review of the fundamentals needed to effectively read a 1D, Linear, Bar Code

Bar codes need to include at least the following:

- **Quiet zone (B_Z)** = the light area before the start character and after the stop character of a bar code. The quiet zone (min. 10 x Module) is needed in order to indicate the start of the bar code to the scanner.
- **Module Size (M)** = the narrowest bar or gap in a bar code
- **Broad bar or gap (Z_B)** = Broad bars or gaps are always a multiple of the module. Module x Ratio = Z_B (Normal Ratio 1:2.5)
- **Length of the bar code (L)** = the length of the bar code including start/stop character (in mm). Depending on definition, the quiet zone must be added or not.
- **Length of a bar (in mm) (S_L)** =



An often misunderstood aspect of selecting the best bar code reader is how to effectively view the bar code. To determine this you will need to identify the following:

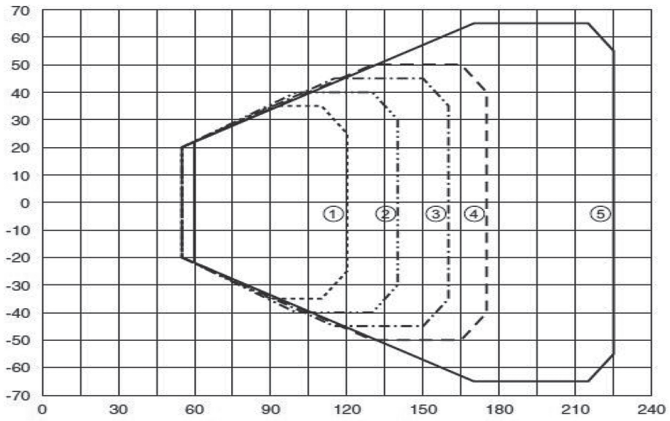
- The minimum distances from the bar code reader to the bar codes being inspected
- The maximum distances from the bar code reader to the bar codes being inspected
- The module size being used
- The code being used

Understanding the ability to use the reading fields will ensure you are using a reader that will perform within the distances you require. The reading field data is taken from the individual Bar Code Reader Technical Manual. These reading fields requirements will vary depending on the laser/imager and the optics selected.

Below are several examples using readers manufactured by Leuze electronic.

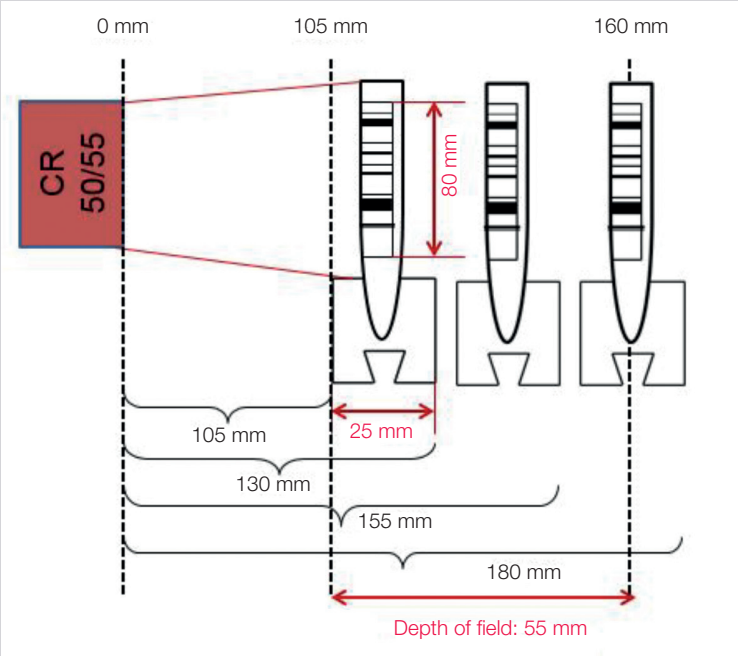
From the **CR55** Technical Manual the following reading field chart is available with 5 examples of module sizes provided.

Please note that the actual reading fields are also influenced by factors such as labeling material, printing quality, scanning angle, printing contrast etc., and may thus deviate from the reading fields specified here. The origin of the read distance always refers to the front edge of the housing of the beam exit.



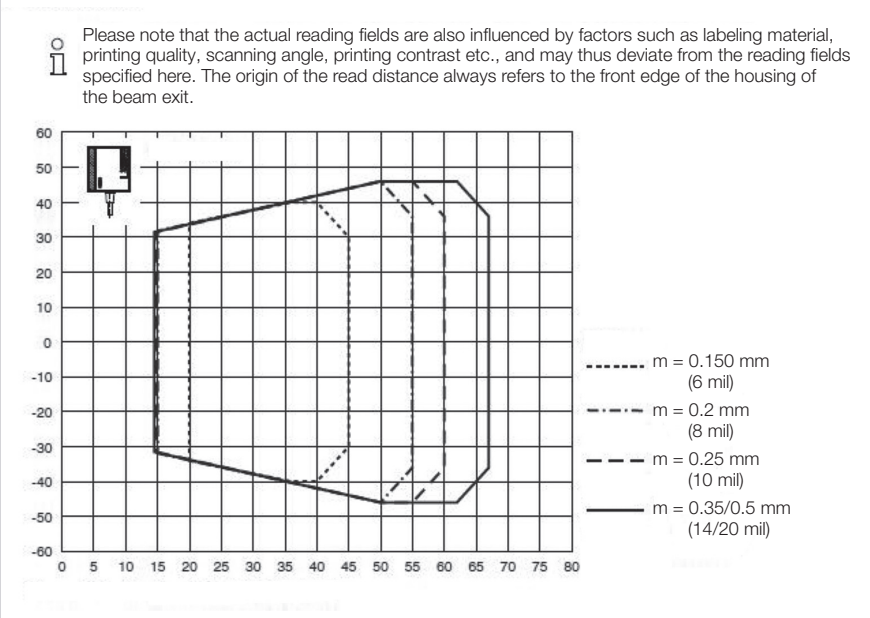
① 5 mil (0.127 mm). Code 128
② 6.5 mil (0.165 mm). Code 128
③ 8 mil (0.203 mm). Code 128
④ 10 mil (0.254 mm). Code 128
⑤ 20 mil (0.508 mm). Code 128

In a real life Laboratory Automation application reading multiple rows of vials using a **CR50/CR55** (CR standard for Code Reader) with a **module code size of 0,2 mm/8mil** provides us the following reading field using standard optics. Note: custom optics may be available.

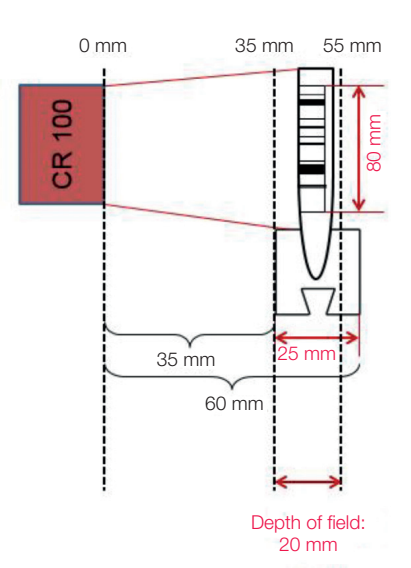


A very important aspect which needs to be taken into account is the length of the bar code (in this case 80 mm height) and how to mount the bar code reader to ensure the correct reading over the whole depth of field. To illustrate this further we will use a second example.

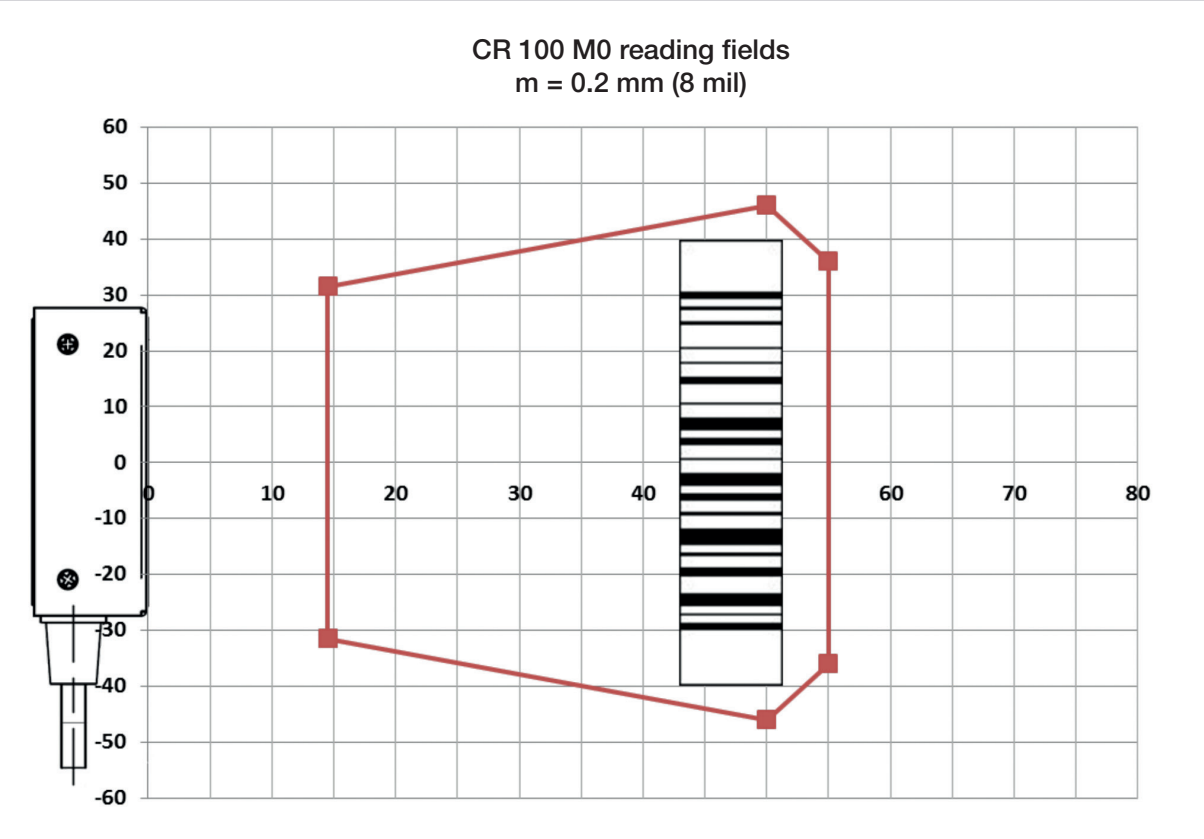
From the **CR100** Technical Manual the following reading field chart is available with 4 examples of module sizes provided. The CR100 is ideal for close in scanner mounting and where a **small Quiet Zone** is required. Note: custom optics may be available.



In Laboratory Automation there are limitations where a bar code reader can be installed mechanically and where the vials under inspection are transported. Using a **CR100** with a **module code size of 0,2 mm/8mil** provides us the following reading field using standard optics. Note: custom optics may be available.



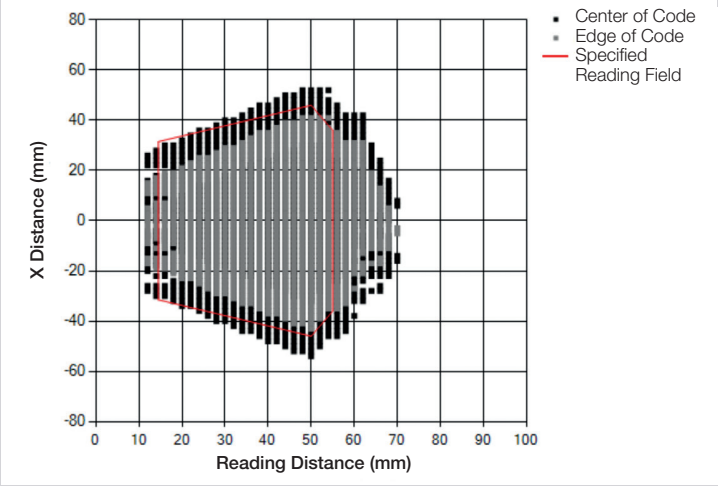
So combining this inside the reading field chart will give us the following chart

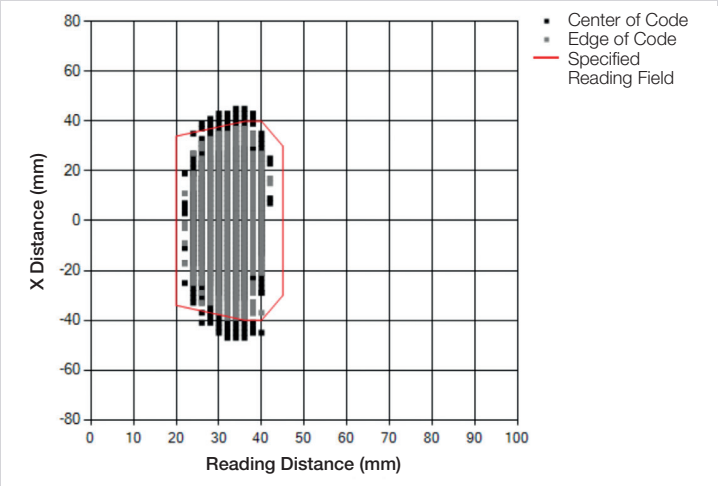


After aligning the bar code reader towards the label inside the reading field another aspect needs to be highlighted. When looking at datasheets of bar code readers you can find sometimes the term “Typical Reading Field”, whereas Leuze is showing guaranteed reading fields. The difference is best explained in the following graphics.

The first graphic shows again the reading field of the CR100 for a Code 128 with the module size of 8 mil. The reading field shown in red can be found on the CR100 data sheet. The black bars indicate the positions the bar code reader was able to correctly decode the label. This is what Leuze calls **Power Reserve**. Even with the typical manufacturing variations, we can always guarantee the correct decoding inside the given reading field. So even if the application would be at the edge of the reading field you can be sure to have a correct reading with all readers.

Contrary to this “Typical Reading Fields” do not take into account variations between the different readers, as shown in the next graphic. So when looking into your application needs, the correct choice of reading field is essential to secure a correct working of your machine.

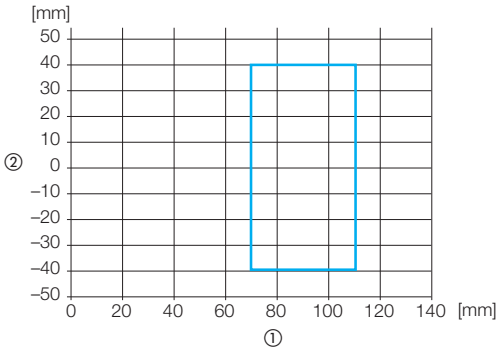




A third example might be of interest for special applications, the need for a higher depth of field for multiple lanes.

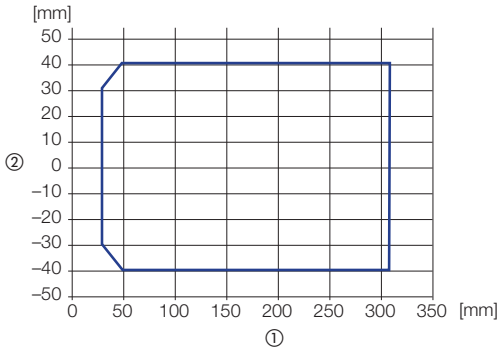
From the **BCL148** Technical Manual the following reading field charts are available with multiple examples of module sizes provided. The BCL148 is ideal for applications where high depth of field is needed. This requires three different reading fields for three different ranges of module size.

Reading curve for module m = 127 µm



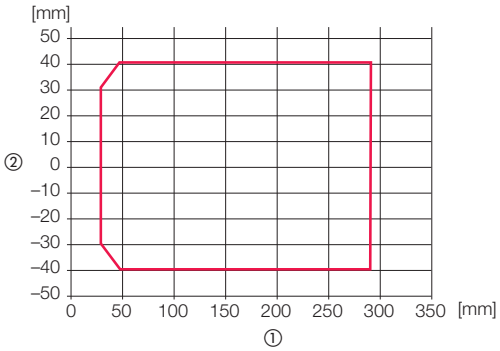
① Reading distance [mm]
② eading field wifth [mm]

Reading curve for module m = 200 … 300 µm



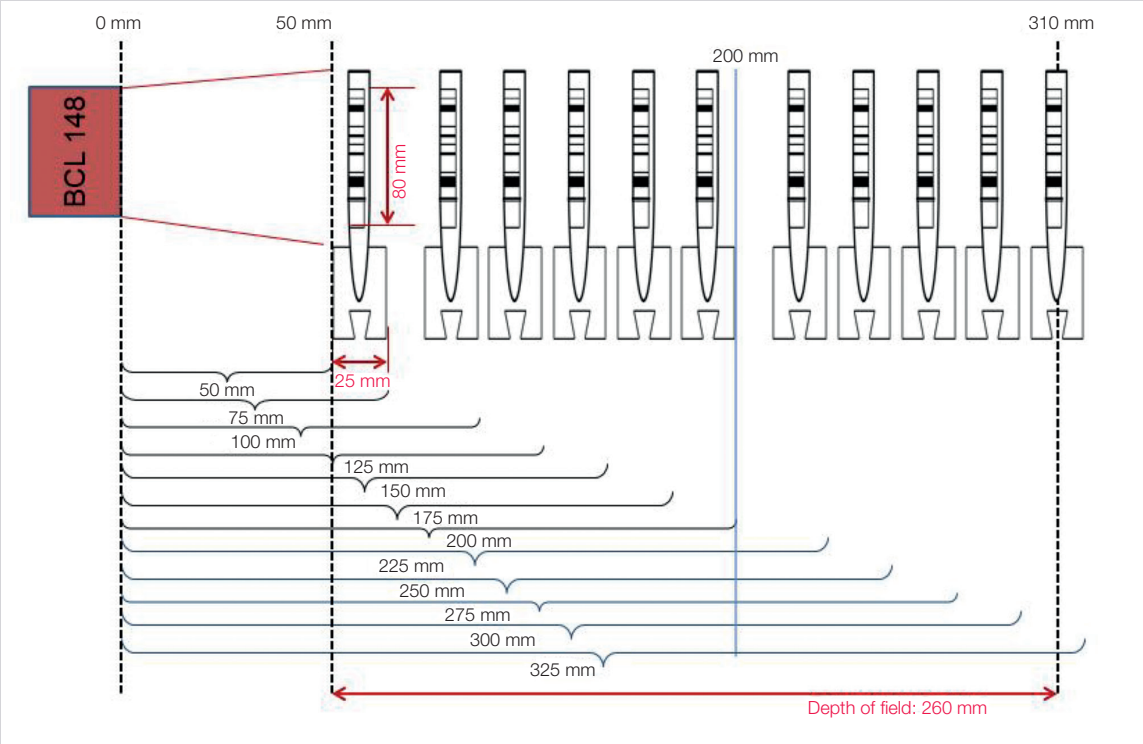
① Reading distance [mm]
② eading field wifth [mm]

Reading curve for module m = 167 … 200 µm



① Reading distance [mm]
② eading field wifth [mm]

In Laboratory Automation there are applications where there are several lanes of vials which need to be inspected. These require a high depth of field to ensure the nearest, the farthest and all vials in between can be read. Using a **BCL148** (BCL standard for Bar Code Laser) with a **module code size of 0,2 mm/8mil** provides us the following reading field using standard optics. Note: custom optics may be available.



Leuze electronic

WE ARE THE SENSOR PEOPLE

For more than 50 years, Leuze electronic has stood for innovative and efficient sensor solutions in the area of factory automation worldwide. Our range of products extends from switching and measuring sensors, identification and data transmission systems to intelligent image processing systems and solutions for safety at work. Our devices operate optically, inductively, with ultrasonic or via RFID, depending on which technology is appropriate for your application. With 18 of our own subsidiaries and 42 sales partners around the world, our customers can reach us quickly and easily everywhere. To accomplish this, we produce our sensors on four continents and can thereby always guarantee product availability. Regardless of when and where the competence of the sensor people happens to be needed at the moment. We are the right partner for both standard applications as well as for custom, high-end solutions. Through an expanded sales and service network, our competent consultation and our reliable customer service, you can count on us to be at your side around the world.

OUR PROMISE TO YOU

YOU'RE SENSOR BUSINESS - SIMPLER AND MORE EFFICIENT

Many companies say they are "customer orientated" – at Leuze electronic, we go a step further.

We offer specific and measurable added value in the areas of USABILITY, APPLICATION KNOW-HOW and SERVICE – to help make our customers more successful. These areas are our yardstick for new product developments, innovative service offerings and extensive market expertise.

SMARTER PRODUCT USABILITY With regard to our product developments, we systematically place emphasis on the especially good usability of all devices. To this end, simple mounting and alignment are taken into account – just as the uncomplicated integrability of the sensors in existing field bus systems and easy configuration, e.g. via a web browser, are.

SMARTER APPLICATION KNOW-HOW Whoever can do it all, can do nothing right. Which is why we concentrate on selected target sectors and applications. There, we are specialists and know all aspects inside out. For this purpose, we optimize our solutions and offer the absolute best solutions from a single source.

SMARTER CUSTOMER SERVICE The technical and personal proximity to our customers, and a skilled, straightforward handling of queries and problems, are among our strengths – and will remain so.

Switching Sensors
Optical Sensors
Ultrasonic Sensors
Fiber Optic Sensors
Inductive Switches
Forked Sensors
Light Curtains
Special Sensors

Measuring Sensors
Distance Sensors
Sensors for Positioning
3D Sensors
Light Curtains
Forked Sensors

Products for Safety at Work
Optoelectronic Safety Sensors
Safe Locking Devices, Switches and Proximity Sensors
Safe Control Components
Machine Safety Services

Identification
Bar Code Identification
2D-Code Identification
RF Identification

Data Transmission/
Control Components
MA Modular Connection Units
Data Transmission
Safe Control Components

Industrial Image Processing
Light-Section Sensors
Smart Camera

Leuze electronic, Inc
55395 Lyon Industrial Drive
New Hudson, MI 48165 / USA
Phone (248) 486-4466
Fax (248) 486-6699
www.leuzeusa.com

us 02-2017/01
Subject to modifications and errors

Leuze electronic

the sensor people

SMART
SENSOR
BUSINESS

BAR CODE DETECTION

White Paper

Chapter 3

LASER BASED BAR CODE READERS

Welcome to Leuze electronic bar code detection 101. This is a collection of chapters to provide you more information about technologies and products to make your life easier and less complicated.

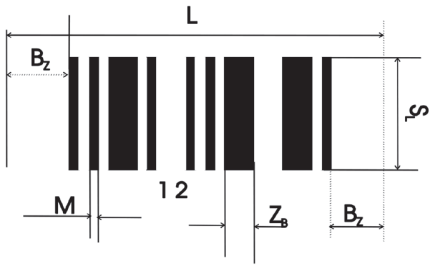
Laser based Bar Code Readers

For many years the use of a laser based bar code reader was the method of choice. There are many reasons why they are beneficial for applications which require one or more of the following:

- Higher depth of field
- Wider field of view requirements
- Low light applications where the laser provides the amount of light needed
- The use of different colors of laser for different depth of fields
- Raster based laser scanners can be used for especially difficult bar codes

Bar codes need to include at least the following:

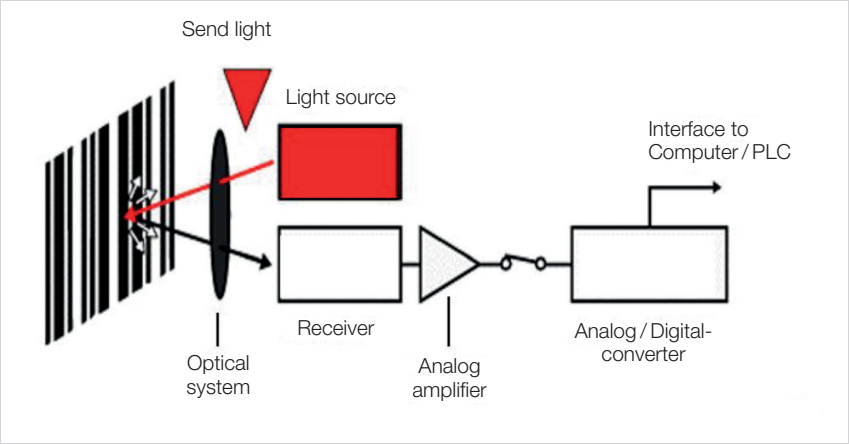
- **Quiet zone (B_Z)** = the light area before the start character and after the stop character of a bar code. The quiet zone (min. 10 x Module) is needed in order to indicate the start of the bar code to the scanner.
- **Module Size (M)** = the narrowest bar or gap in a bar code
- **Broad bar or gap (Z_B)** = Broad bars or gaps are always a multiple of the module. Module x Ratio = Z_B (Normal Ratio 1:2.5)
- **Length of the bar code (L)** = the length of the bar code including start/stop character (in mm). Depending on definition, the quiet zone must be added or not.
- **Length of a bar (in mm) (S_L)** =



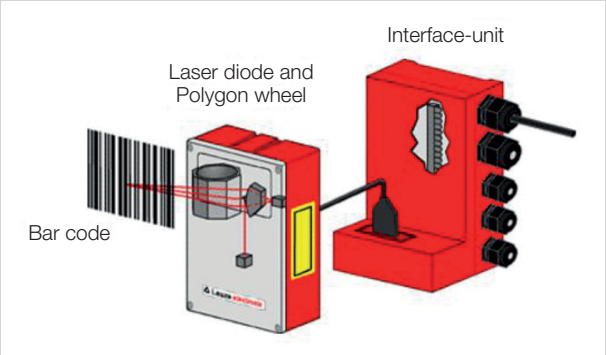
By using a laser diode and a combination of a spinning polygon wheel the bar code laser system provides a very effective reading solution. The following graphics will provide greater detail.

PRINCIPLES OF BAR CODE READING IN GENERAL

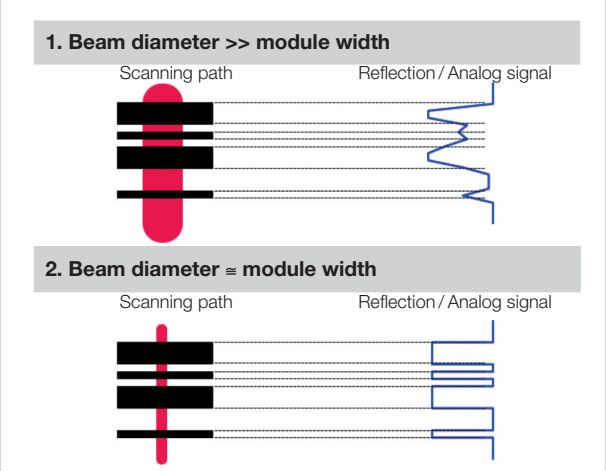
A **laser based Bar Code** reader uses a laser diode in combination with a spinning polygon wheel to properly align themselves for effective reading of a linear bar code.



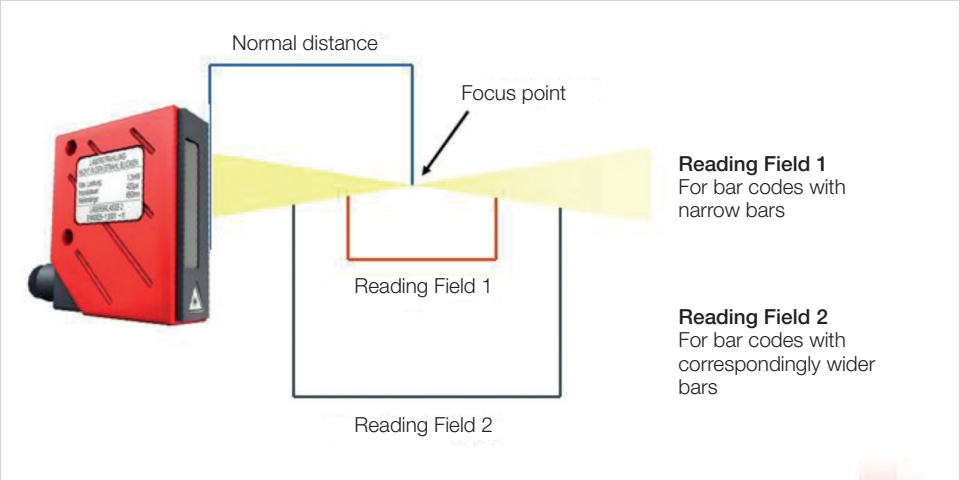
Identification Resolution / Beam Diameter provide a further understanding of why the reading field and module size are so important. To effectively choose the best Laser Bar Code Reader requires a combination of module size and reading field requirement.



Another important characteristic to take into account is the focus point where the laser is optimally focused for the given module size.



Different optics can be configured for different reading field requirements.



Examples of Leuze electronic products:

The Leuze electronic BCL 148 gives a reading distance up to 250 mm providing the ability of **reading between 1 – 15 rows of racks with focus adjustment.**

- Scanner with focus adjustment for sample codes and reagents
- Reading field depth of up to 250 mm
- Resolutions of 127 µm codes in a broad area over multiple rows of racks are possible
- Maximum scanning rate of 750 scans/s also makes quick manual or automated rack insertions possible
- Optional frontal or lateral beam exit
- Because of the focus adjustment, even the first scan can be used for reading the code, thereby allowing the decoding to be verified multiple times

The Leuze electronic BCL 8 is suited for **reading of 1 – 2 rows of racks or in sorters.** With the ability to consistently provide a high scanning rate (up to 600 scans/s) which facilitates reliable reading with Power Reserve built in.

- Consistently high scanning rate (up to 600 scans/s) facilitates reliable reading, even with manual insertion
- Robust IP 67 design with metal housing and glass front
- Integrated daisy chain network via RS 232 interface
- Various optics models for codes from 127 – 500 µm
- Standard extensive firmware is provided for most application needs. The flexibility of the BCL allows for customization as needed and when requirements are beyond the standard firmware capabilities.

The Leuze electronic BCL 21/22 is available for **reading of 1 – 6 rows of racks or in sorters.** This is achieved by a high-performance laser scanner with different optics models available for different reading field requirements.

- High-performance laser scanner with different optics models
- High scanning rate of up to 1,000 scans/s for the fastest movements, such as manual insertion and in conveyor systems for samples
- N-optics for high-resolution codes with module size from 150 µm
- Simple configuration of the desired configuration via online commands or with permanent settings in the firmware
- Raster scanner optionally available

The Leuze electronic BCL 300i is able to provide **reading of up to 6 rows of racks.** This series provides the most options available to allow us to customize a standard solution for you. These include different optics, interfaces, laser mirror options, integrated display and integrator heater.

- Reading distances 80 – 450 mm
- Modular connection technology by means of pluggable connection hoods with M12 connector, clamp connection or fixed connection cable
- High scanning rate of up to 1,000 scans/s for the fastest movements, such as manual insertion and in conveyor systems for samples
- Variants: Line scanner and deflecting mirror
- Raster scanner optionally available
- Code reconstruction technology (CRT) for reliable identification of damaged codes
- Optional display built into the reader
- Models can be configured with an optional heater for Lab Storage applications to provide for temperatures to –35 C°

Leuze electronic

WE ARE THE SENSOR PEOPLE

For more than 50 years, Leuze electronic has stood for innovative and efficient sensor solutions in the area of factory automation worldwide. Our range of products extends from switching and measuring sensors, identification and data transmission systems to intelligent image processing systems and solutions for safety at work. Our devices operate optically, inductively, with ultrasonic or via RFID, depending on which technology is appropriate for your application. With 18 of our own subsidiaries and 42 sales partners around the world, our customers can reach us quickly and easily everywhere. To accomplish this, we produce our sensors on four continents and can thereby always guarantee product availability. Regardless of when and where the competence of the sensor people happens to be needed at the moment. We are the right partner for both standard applications as well as for custom, high-end solutions. Through an expanded sales and service network, our competent consultation and our reliable customer service, you can count on us to be at your side around the world.

SMART SENSOR BUSINESS

OUR PROMISE TO YOU

YOUR SENSOR BUSINESS – SIMPLER AND MORE EFFICIENT

Many companies say they are “customer orientated” – at Leuze electronic, we go a step further.

We offer specific and measurable added value in the areas of USABILITY, APPLICATION KNOW-HOW and SERVICE – to help make our customers more successful. These areas are our yardstick for new product developments, innovative service offerings and extensive market expertise.

SMARTER PRODUCT USABILITY With regard to our product developments, we systematically place emphasis on the especially good usability of all devices. To this end, simple mounting and alignment are taken into account – just as the uncomplicated integrability of the sensors in existing field bus systems and easy configuration, e.g. via a web browser, are.

SMARTER APPLICATION KNOW-HOW Whoever can do it all, can do nothing right. Which is why we concentrate on selected target sectors and applications. There, we are specialists and know all aspects inside out. For this purpose, we optimize our solutions and offer the absolute best solutions from a single source.

SMARTER CUSTOMER SERVICE The technical and personal proximity to our customers, and a skilled, straightforward handling of queries and problems, are among our strengths – and will remain so.

Switching Sensors
Optical Sensors
Ultrasonic Sensors
Fiber Optic Sensors
Inductive Switches
Forked Sensors
Light Curtains
Special Sensors

Measuring Sensors
Distance Sensors
Sensors for Positioning
3D Sensors
Light Curtains
Forked Sensors

Products for Safety at Work
Optoelectronic Safety Sensors
Safe Locking Devices, Switches and Proximity Sensors
Safe Control Components
Machine Safety Services

Identification
Bar Code Identification
2D-Code Identification
RF Identification

Data Transmission/
Control Components
MA Modular Connection Units
Data Transmission
Safe Control Components

Industrial Image Processing
Light-Section Sensors
Smart Camera

Leuze electronic, Inc
55395 Lyon Industrial Drive
New Hudson, MI 48165 / USA
Phone (248) 486-4466
Fax (248) 486-6699
www.leuzeusa.com

us 02-2017/01
Subject to modifications and errors