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OPTIPACT IN **A**UTOMATED **G**UIDED **V**EHICLES (AGV)

(AN APPLICATION NOTE)

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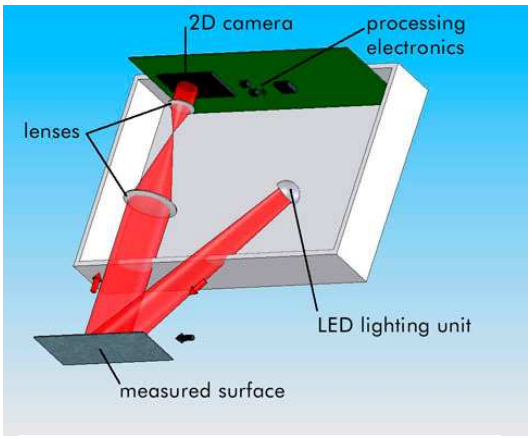


OPTIPACT TECHNOLOGY

IMAGE CORRELATION

(Consecutive images are compared and the difference in position of the distinct markings corresponds to the 2D movement.)

Synopsis

The application note describes why OPTIPACT is an ideal solution and an enhancement to AGV measurement applications. At the outset, OPT is compact in design and easily mountable through a straightforward installation. It does not require any additional components hence comparatively cheaper than the current technologies in place. OPT uses non-contact measurement principle and attains output of good resolution (up to 10µm) and very high accuracies (measurement uncertainty < 1%). The whole sensor is highly protected from external contaminants with a high protection class of IP65.

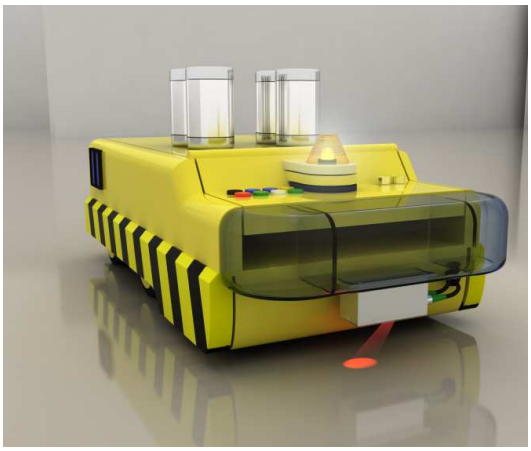
The **A**utomated **G**uided **V**ehicle (AGV) is a material handling robot, ideally used for shifting of materials within an industry but without any manual support or intervention. The main scope of OPTIPACT (OPT) in AGV applications is for the precise measurement of velocity and distance traversed. Automated Guided Vehicles (AGVs) are widely used in industries such as Automotive, Manufacturing, Distribution centers and Pharmaceuticals to move material around. OPT in AGVs can measure both the distance travelled, the velocity and can also raise alarms in case of inappropriate movement. The OPT also has an added advantage of measuring under dynamic conditions-such as deviation of working distance and also 2D directional measurement.

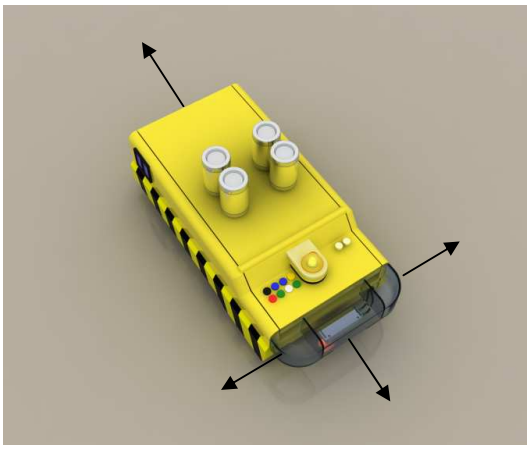
To summarize in one line, OPT is a compact, cheap, flexible and an accurate measurement system with good ingress protection and capable of measuring over dynamic conditions with utmost precision.

Technology

The AGVs use wired tracks, magnetic guide tapes, laser guides or rotary encoders coupled with the wheel shafts and measurement wheels to navigate the AGV. Although these systems work well they have their own disadvantages. For example, RF transmitting wires embedded into the surface of movement are expensive and an immutable solution. Even if the tape guides present a low cost solution, the main disadvantages of these systems are that multiple or cross tracks cannot be easily traced by the AGV.

Mechanical measurement solutions like the rotary encoders or measurement wheels generally have a mechanical slippage during measurement and this considerably reduces the accuracy. The non-contact laser target navigation mechanism which is extensively used nowadays is accurate but a costly method of measurement since it requires suitable transmitters and receivers.





The **OPT** uses a very simple non-contact, slippage free measurement principle. It is basically a simple correlation method whereby the surface is observed by a camera suitably illuminated by appropriate light sources. Displacement, direction and velocity are analyzed and calculated by comparing consecutive high resolution surface pictures. Image correlation relies on image overlaps within a captured sequence of images. The OPT has different models varying in the range of measurement velocity, illumination (LED, Laser) and the optics used for focus, making it suitable for flexible measurements over a wide range of measurement surfaces and velocities.

OPT in Automated Guided Vehicles (AGV)

WHY USE OPTIPACT IN AGV's?

The OPTIPACT is attached as an external input device to AGV, so as to provide input signals, enabling safe and automated material movement. Ultimately, it helps in accurate path guidance configuration.

Mounting

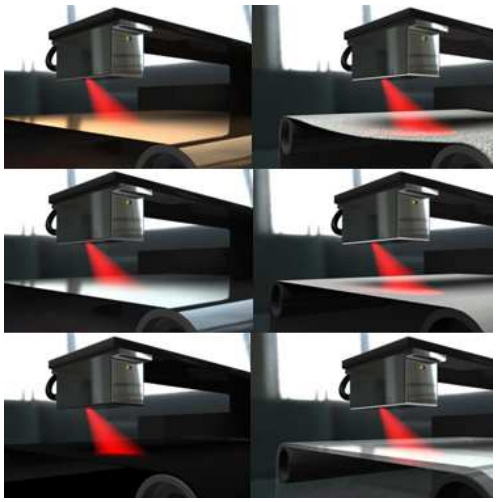
Since, the OPT does not require any additional accessories for measurement, the installation of OPT is very easy and straightforward. There is a particular working distance with a flexible deviation of up to 20% which has to be maintained for accurate measurement.

The AGV application is a mobile application and requires the related measurement to be done dynamically too. This flexibility in measurement conditions is an advantage for measurement over uneven surfaces. The OPT too is a very flexible and ideal for dynamic measurement. Generally, in AGVs the OPTIPACT is mounted under the chassis as shown in the picture above. The OPTIPACT can be mounted virtually anywhere as it has its own illumination and it is also not easily affected by external contaminants because of high Ingress protection (of up to IP65).

- **Non-Contact Principle**

The optical non-contact principle of measurement in OPT is very simple and convenient to use on AGVs. It does not require any additional accessories, can measure over any surface and has its own illumination making it a less expensive, flexible and convenient solution. But, the most important aspect is that there is no slippage in measurements as in measurements with encoders coupled to the shaft or using measurement wheels. Good resolutions of up to 10µm and errors < 1% are achievable in 2 dimensions as shown above.

	OPTIPACT		
	L	F	S
Velocity Range	±4m/s (±780ft/min)	±1m/s (±180ft/min)	±4m/s (±780ft/min)
Working Distance to Object[1]	30mm (1.2in)	15.5mm (0.6in)	40mm (1.6in)
Distance Deviation	±20%	±10%	±10%
Resolution[2]	10µm	15µm	65µm
Measurement Uncertainty[3]	< 1%		
Supply Voltage	10-30V, 5V		
Power Consumption	2.5W		
Illumination	IR Laser[4]	Red LED	
Interfaces	Incremental RS232		
Protection Degree	IP65		
Working Temperature	-5 - 55°C (5-131 °F)		



• Velocity Switch (Digital Output)

The OPTIPACT has a unique feature of being able to produce alarm outputs if the measurement parameter exceeds a particular value. Mostly, AGV manufacturers use this alarm or digital output feature as a safety to indicate if the AGV has exceeded a particular velocity/acceleration. OPTIPACT can be programmed to raise alarms if it deviates from a particular surface too using the above provisions.

• Navigation Guidance

There are basically two different navigations for AGVs -fixed path and free ranging navigation.

- **Fixed Path:** Involves pre-defined start, stop and navigation points. OPTIPACT's accurate incremental signals interfaced with the control systems provide the least uncertainty in fixed path navigation.
- **Free-ranging navigation:** Requires velocity measurement, distance calculation and additional safety features, all provided by OPT as a single entity.

• Flexibility

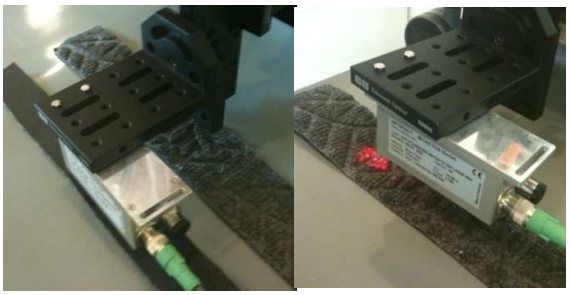
The AGV is a mobile application and therefore the measurement environment is constantly varying. The sensor used for such measurements and feedback should be capable of producing an accurate output even under dynamic conditions.

Usually, there is a shift in centre of gravity of AGVs carrying heavy loads when negotiating bends. This coupled with imperfect traction between the wheels and floor can cause slippages. OPT is a non-contact and flexible measurement system having a wide range of working distance and the deviations due to loading will not affect the measurements. Also, as opposed to the 1D measurement of rotary encoders, the OPTIPACT sensors allow measurements of position and velocity, in 2D and are useful in detecting and correcting any deviations of the AGVs from its planned path. The flexibility in navigation and the capability of measuring in the dynamic environment make OPTIPACT the ideal solution for AGV applications.

• Measurement Surfaces

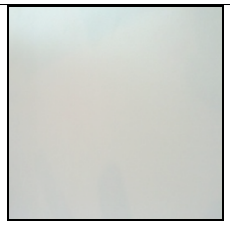
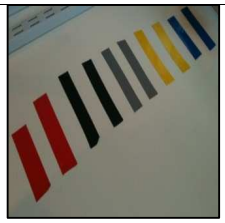
Unlike wired sensors and guide tape sensors, OPTIPACTs do not need any special surfaces to work on. OPTIPACTs were mainly tested on sealed concrete floor as well as black/yellow striped tape floor, two types of floor surfaces that would typically be encountered in an industrial environment, and found to be performing well with a high level of accuracy (i.e. measurement error lesser than 1% of distance measured). Further simple tests show that OPTIPACT performed well over shiny surfaces, rough punch carpets, colored tapes and all such surfaces.

APPENDIX A: AGV APPLICATION SIMULATOR

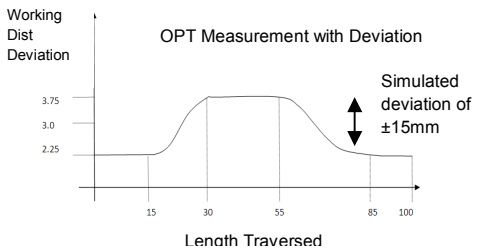


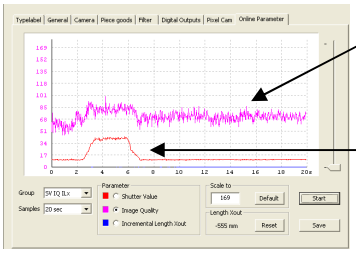
The AGV simulator is simple setup where the OPT is mounted on a movable platform on wheels just as in the AGV (under the chassis). Simple measurement tests were conducted to test the measurement statistics, the flexibility of measurements etc.

- **Measurement over Different Surfaces using OPT-L**

					
Shiny White Surface		**Coloured Strips**		**Rough Punch**	
+ve Error Max:	0.64%	**+ve Error Max:**	0.83%	**+ve Error Max:**	0.75%
-ve Error Max:	-0.84%	**-ve Error Max:**	-0.69%	**-ve Error Max:**	-0.67%
Absolute Meas Err:	0.12%	**Absolute Meas Err:**	0.2%	**Absolute Meas Err:**	0.4%
The error is less than 1% in all the measurements over various surfaces of measurements.					

- **Measurement over deviation in working distance using OPT-L**





-ve Error Max:	-0.9 %
+ve Error Max:	0.71%
Absolute Measurement Error:	0.23%
The contour of the deviation and the smart adaptation of the OPT (adjusts shutter value to maintain the image quality) are shown above. Even with deviation of working distance the Image quality is kept constant providing accurate measurement.	

Error Calculation: If X is the actual length and X' is the measured length. $(X - X') = \pm\Delta X$

+ve Error Max= $[(\Delta X)/X)]\%$

-ve Error Max= $[(-\Delta X)/X)]\%$

Absolute Meas Error= $\Sigma[(\pm\Delta X)/X)]\%$

APPENDIX B: SELECTION OF APPROPRIATE OPTIPACT MODEL

Step 1: *Identify maximum possible working distance*

The **OPT-L** has the largest working distance variation of 30 mm ± 6 mm (1.18 in ± 0.3 in), the **OPT-S** has a working distance of 40 mm ± 4 mm (1.57 in ± 0.15 in) and **OPT-F** has the minimum, 15.5 mm ± 1.5 mm (0.61 in ± 0.06 in). The differences are due to the different optics, illumination and lenses used.

Step 2: *Identify the measurement surface*

The surfaces that can be measured, range from the smoothest of surfaces like rubber, plastic, molded floors to the coarsest like punch carpets, graveled path etc. Hence the correct OPT needs to be used according to the surface to be measured upon.

The **OPT-S** is an average measurement system capable of measuring over surfaces with good optical structures caused roughness and varying reflectivity.

The increased optical resolution of **OPT-F** enables applications on materials (such as regular photocopying paper) with very fine surface structures, imperceptible at first glance to the human eye.

The **OPT-L** has an internal laser illumination instead of a visible LED illumination, hence, measures on very smooth surfaces with structures imperceptible to the human eye. This is particularly true for reflective or glossy materials too. Motion can also be well detected on materials that appear to have a homogeneous structure.

Step 3: *Identify working conditions and tentative ranges of measurement*

The **OPT-S** is the typical mid range sensor with velocity range up to ± 4 m/s (13 ft/s) and the **OPT-F** corresponds to a smaller velocity range of ± 1 m/s (180 ft/min), but the new **OPT-L** can measure speeds up to ±4m/s (800ft/min).

P.S: The OPT-M is not suitable for AGV applications due to its larger size and suitability in specific industrial applications only.

Release Notes

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Reviewed By : CWA, ILA, CDS

For more detailed information:

OPTIPACT

Other Applications