APÉNDICE A
ELEMENTOS USADOS

Philips Semiconductors — Product specification

NPN switching transistors — 2N2222; 2N2222A

FEATURES

- High current (max. 800 mA)
- Low voltage (max. 40 V).

APPLICATIONS

- Linear amplification and switching.

DESCRIPTION

NPN switching transistor in a TO-18 metal package.
PNP complement: 2N2907A.

PINNING

PIN	DESCRIPTION
1	emitter
2	base
3	collector, connected to case

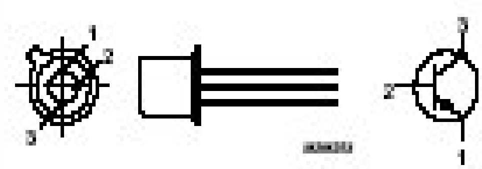


Fig.1 Simplified outline (TO-18) and symbol.

QUICK REFERENCE DATA

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	2N2222		–	60	V
	2N2222A		–	75	V
V_{CEO}	collector-emitter voltage	open base			
	2N2222		–	30	V
	2N2222A		–	40	V
I_C	collector current (DC)		–	800	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25\,°C$	–	500	mW
h_{FE}	DC current gain	I_C = 10 mA; V_{CE} = 10 V	75	–	
f_T	transition frequency	I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz			
	2N2222		250	–	MHz
	2N2222A		300	–	MHz
t_{off}	turn-off time	I_{Con} = 150 mA; I_{Bon} = 15 mA; I_{Boff} = −15 mA	–	250	ns

NPN switching transistors 2N2222; 2N2222A

LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CBO}	collector-base voltage	open emitter			
	2N2222		–	60	V
	2N2222A		–	75	V
V_{CEO}	collector-emitter voltage	open base			
	2N2222		–	30	V
	2N2222A		–	40	V
V_{EBO}	emitter-base voltage	open collector			
	2N2222		–	5	V
	2N2222A		–	6	V
I_C	collector current (DC)		–	800	mA
I_{CM}	peak collector current		–	800	mA
I_{BM}	peak base current		–	200	mA
P_{tot}	total power dissipation	$T_{amb} \leq 25$ °C	–	500	mW
		$T_{case} \leq 25$ °C	–	1.2	W
T_{stg}	storage temperature		–65	+150	°C
T_j	junction temperature		–	200	°C
T_{amb}	operating ambient temperature		–65	+150	°C

THERMAL CHARACTERISTICS

SYMBOL	PARAMETER	CONDITIONS	VALUE	UNIT
$R_{th\ j\text{-}a}$	thermal resistance from junction to ambient	in free air	350	K/W
$R_{th\ j\text{-}c}$	thermal resistance from junction to case		146	K/W

TIP120/121/122
TIP125/126/127

COMPLEMENTARY SILICON POWER DARLINGTON TRANSISTORS

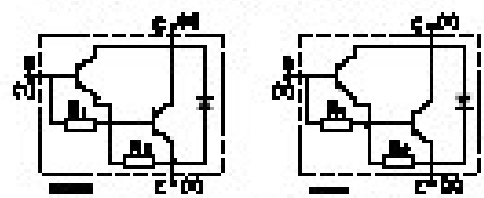
- STMicroelectronics PREFERRED SALESTYPES

DESCRIPTION

The TIP120, TIP121 and TIP122 are silicon Epitaxial-Base NPN power transistors in monolithic Darlington configuration mounted in Jedec TO-220 plastic package. They are intented for use in power linear and switching applications. The complementary PNP types are TIP125, TIP126 and TIP127, respectively.

TO-220

INTERNAL SCHEMATIC DIAGRAM



R_1 Typ. = 5 KΩ R_2 Typ. = 150 Ω

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter		Value			Unit
		NPN	TIP120	TIP121	TIP122	
		PNP	TIP125	TIP126	TIP127	
V_{CBO}	Collector-Base Voltage (I_E = 0)		60	80	100	V
V_{CEO}	Collector-Emitter Voltage (I_B = 0)		60	80	100	V
V_{EBO}	Emitter-Base Voltage (I_C = 0)		5			V
I_C	Collector Current		5			A
I_{CM}	Collector Peak Current		8			A
I_B	Base Current		0.1			A
P_{tot}	Total Dissipation at $T_{case} \leq 25$ °C $T_{amb} \leq 25$ °C		65 2			W W
T_{stg}	Storage Temperature		-65 to 150			°C
T_j	Max. Operating Junction Temperature		150			°C

* For PNP types voltage and current values are negative.

THERMAL DATA

$R_{thj-case}$	Thermal Resistance Junction-case	Max	1.92	°C/W
$R_{thj-amb}$	Thermal Resistance Junction-ambient	Max	62.5	°C/W

ELECTRICAL CHARACTERISTICS (T_{case} = 25 °C unless otherwise specified)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
I_{CEO}	Collector Cut-off Current (I_B = 0)	for TIP120/125 V_{CE} = 30 V for TIP121/126 V_{CE} = 40 V for TIP122/127 V_{CE} = 50 V			0.5 0.5 0.5	mA mA mA
I_{CBO}	Collector Cut-off Current (I_E = 0)	for TIP120/125 V_{CB} = 60 V for TIP121/126 V_{CB} = 80 V for TIP122/127 V_{CB} = 100 V			0.2 0.2 0.2	mA mA mA
I_{EBO}	Emitter Cut-off Current (I_C = 0)	V_{EB} = 5 V			2	mA
$V_{CEO(sus)}$*	Collector-Emitter Sustaining Voltage (I_B = 0)	I_C = 30 mA for TIP120/125 for TIP121/126 for TIP122/127	 60 80 100			 V V V
$V_{CE(sat)}$*	Collector-Emitter Saturation Voltage	I_C = 3 A I_B = 12 mA I_C = 5 A I_B = 20 mA			2 4	V V
$V_{BE(on)}$*	Base-Emitter Voltage	I_C = 3 A V_{CE} = 3 V			2.5	V
h_{FE}*	DC Current Gain	I_C = 0.5 A V_{CE} = 3 V I_C = 3 A V_{CE} = 3 V	1000 1000			

* Pulsed: Pulse duration = 300 µs, duty cycle ≤ 2 %
For PNP types voltage and current values are negative.

Philips Semiconductors | Product specification

Hex inverting Schmitt trigger — 74HC14; 74HCT14

FEATURES

- Applications:
  - Wave and pulse shapers
  - Astable multivibrators
  - Monostable multivibrators.
- Complies with JEDEC standard no. 7A
- ESD protection:
  HBM EIA/JESD22-A114-A exceeds 2000 V
  MM EIA/JESD22-A115-A exceeds 200 V.
- Specified from −40 to +85 °C and −40 to +125 °C.

DESCRIPTION

The 74HC14 and 74HCT14 are high-speed Si-gate CMOS devices and are pin compatible with low power Schottky TTL (LSTTL). They are specified in compliance with JEDEC standard no. 7A.

The 74HC14 and 74HCT14 provide six inverting buffers with Schmitt-trigger action. They are capable of transforming slowly changing input signals into sharply defined, jitter-free output signals.

QUICK REFERENCE DATA

GND = 0 V; T_{amb} = 25 °C; $t_r = t_f$ = 6 ns

SYMBOL	PARAMETER	CONDITIONS	TYPICAL		UNIT
			HC	HCT	
t_{PHL}/t_{PLH}	propagation delay nA to nY	C_L = 15 pF; V_{CC} = 5 V	12	17	ns
C_I	input capacitance		3.5	3.5	pF
C_{PD}	power dissipation capacitance per gate	notes 1 and 2	7	8	pF

Notes

1. C_{PD} is used to determine the dynamic power dissipation (P_D in μW):
   $P_D = C_{PD} \times V_{CC}^2 \times f_i \times N + \Sigma(C_L \times V_{CC}^2 \times f_o)$ where:
   f_i = input frequency in MHz;
   f_o = output frequency in MHz;
   C_L = output load capacitance in pF;
   V_{CC} = supply voltage in Volts;
   N = total load switching outputs;
   $\Sigma(C_L \times V_{CC}^2 \times f_o)$ = sum of the outputs.
2. For type 74HC14 the condition is V_I = GND to V_{CC}.
   For type 74HCT14 the condition is V_I = GND to V_{CC} − 1.5 V.

Hex inverting Schmitt trigger — 74HC14; 74HCT14

FUNCTION TABLE

INPUT	OUTPUT
nA	nY
L	H
H	L

Note

1. H = HIGH voltage level;
   L = LOW voltage level.

ORDERING INFORMATION

TYPE NUMBER	PACKAGE				
	TEMPERATURE RANGE	PINS	PACKAGE	MATERIAL	CODE
74HC14D	−40 to +125 °C	14	SO14	plastic	SOT108-1
74HCT14D	−40 to +125 °C	14	SO14	plastic	SOT108-1
74HC14DB	−40 to +125 °C	14	SSOP14	plastic	SOT337-1
74HCT14DB	−40 to +125 °C	14	SSOP14	plastic	SOT337-1
74HC14N	−40 to +125 °C	14	DIP14	plastic	SOT27-1
74HCT14N	−40 to +125 °C	14	DIP14	plastic	SOT27-1
74HC14PW	−40 to +125 °C	14	TSSOP14	plastic	SOT402-1
74HCT14PW	−40 to +125 °C	14	TSSOP14	plastic	SOT402-1
74HC14BQ	−40 to +125 °C	14	DHVQFN14	plastic	SOT762-1
74HCT14BQ	−40 to +125 °C	14	DHVQFN14	plastic	SOT762-1

PINNING

PIN	SYMBOL	DESCRIPTION
1	1A	data input
2	1Y	data output
3	2A	data input
4	2Y	data output
5	3A	data input
6	3Y	data output
7	GND	ground (0 V)
8	4Y	data output
9	4A	data input
10	5Y	data output
11	5A	data input
12	6Y	data output
13	6A	data input
14	V_{CC}	supply voltage

Philips Semiconductors | Product specification

Hex inverting Schmitt trigger — 74HC14; 74HCT14

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	CONDITIONS	74HC14			74HCT14			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
V_{CC}	supply voltage		2.0	5.0	6.0	4.5	5.0	5.5	V
V_I	input voltage		0	–	V_{CC}	0	–	V_{CC}	V
V_O	output voltage		0	–	V_{CC}	0	–	V_{CC}	V
T_{amb}	operating ambient temperature	see DC and AC characteristics per device	–40	+25	+85	–40	+25	+85	°C
			–40	–	+125	–40	–	+125	°C

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 60134); voltages are referenced to GND (ground = 0 V).

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
V_{CC}	supply voltage		–0.5	+7	V
I_{IK}	input diode current	$V_I < -0.5$ V or $V_I > V_{CC} + 0.5$ V	–	±20	mA
I_{OK}	output diode current	$V_O < -0.5$ V or $V_O > V_{CC} + 0.5$ V	–	±20	mA
I_O	output source or sink current	$-0.5\ V < V_O < V_{CC} + 0.5$ V	–	±25	mA
I_{CC}; I_{GND}	V_{CC} or GND current		–	50	mA
T_{stg}	storage temperature		–65	+150	°C
P_{tot}	power dissipation	T_{amb} = –40 to +125 °C			
		DIP14 packages; note 1	–	750	mW
		Other packages; note 2	–	500	mW

Notes

1. For DIP14 packages: above 70 °C the value of P_D derates linearly with 12 mW/K.
2. For SO14 packages: above 70 °C the value of P_D derates linearly with 8 mW/K.
   For (T)SSOP14 packages: above 60 °C the value of P_D derates linearly with 5.5 mW/K.
   For DHVQFN14 packages: above 60 °C the value of P_D derates linearly with 4.5 mW/K.

Vishay Telefunken

Application of Optical Reflex Sensors

TCRT1000, TCRT5000, CNY70

Vishay Telefunken optoelectronic sensors contain infrared-emitting diodes as a radiation source and phototransistors as detectors.

Typical applications include:

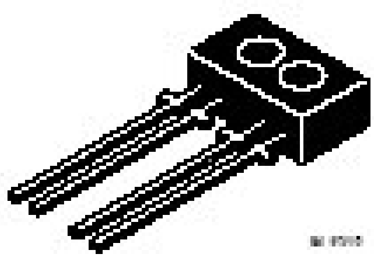
- Copying machines
- Video recorders
- Proximity switch
- Vending machines
- Printers
- Object counters
- Industrial control

Special features:

- Compact design
- Operation range 0 to 20 mm
- High sensitivity
- Low dark current
- Minimized crosstalk
- Ambient light protected
- Cut-off frequency up to 40 kHz
- High quality level, ISO 9000
- Automated high-volume production

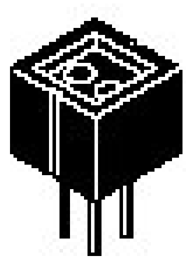
These sensors present the quality of perfected products. The components are based on Vishay Telefunken's many years' experience as one of Europe's largest producers of optoelectronic components.

Sensor Drawings



TCRT1000

TCRT5000



CNY70

Vishay Telefunken

Table 1. Relative collector current (or coupling factor) of the reflex sensors for reflection on various materials. Reference is the white side of the Kodak neutral card. The sensor is positioned perpendicular to the surface. The wavelength is 950 nm.

Kodak neutral card	
White side (reference medium)	100%
Gray side	20%
Paper	
Typewriting paper	94%
Drawing card, white (Schoeller Durex)	100%
Card, light gray	67%
Envelope (beige)	100%
Packing card (light brown)	84%
Newspaper paper	97%
Pergament paper	30-42%
Black on white typewriting paper	
Drawing ink (Higgins, Pelikan, Rotring)	4-6%
Foil ink (Rotring)	50%
Fiber-tip pen (Edding 400)	10%
Fiber-tip pen, black (Stabilo)	76%
Photocopy	7%
Plotter pen	
HP fiber–tip pen (0.3 mm)	84%
Black 24 needle printer (EPSON LQ-500)	28%
Ink (Pelikan)	100%
Pencil, HB	26%

Plastics, glass	
White PVC	90%
Gray PVC	11%
Blue, green, yellow, red PVC	40-80%
White polyethylene	90%
White polystyrene	120%
Gray pertinax	9%
Fiber glass board material	
Without copper coating	12-19%
With copper coating on the reverse side	30%
Glass, 1 mm thick	9%
Plexiglass, 1 mm thick	10%
Metals	
Aluminum, bright	110%
Aluminum, black anodized	60%
Cast aluminum, matt	45%
Copper, matt (not oxidized)	110%
Brass, bright	160%
Gold plating, matt	150%
Textiles	
White cotton	110%
Black velvet	1.5%

Parameters and Practical Use of the Reflex Sensors

A reflex sensor is used in order to receive a reflected signal from an object. This signal gives information on the position, movement, size or condition (e.g. coding) of the object in question. The parameter that describes the function of the optical coupling precisely is the so-called optical transfer function (OT) of the sensor. It is the ratio of the received to the emitted radiant power.

$$OT = \frac{\Phi_r}{\Phi_e}$$

Additional parameters of the sensor, such as operating range, the resolution of optical distance of the object, the sensitivity and the switching point in the case of local changes in the reflection, are directly related to this optical transfer function.

In the case of reflex sensors with phototransistors as receivers, the ratio I_C/I_F (the ratio of collector current I_C to the forward current I_F) of the diode emitter is preferred to the optical transfer function. As with optocouplers, I_C/I_F is generally known as the coupling factor, k. The following approximate relationship exists between k and OT:

$$k = I_C / I_F = [(S \times B)/h] \times \Phi_r/\Phi_e$$

where B is the current amplification, $S = I_b/\Phi_r$ (phototransistor's spectral sensitivity), and $h = I_F/\Phi_e$ (proportionality factor between I_F and Φ_e of the transmitter).

In figures 1 and 2, the curves of the radiant intensity, I_e, of the transmitter to the forward current, I_F and the sensitivity of the detector to the irradiance, E_e, are shown respectively. The gradients of both are equal to unity slope.

This represents a measure of the deviation of the curves from the ideal linearity of the parameters. There is a good proportionality between I_e and I_F and between I_C and E_e where the curves are parallel to the unity gradient.

Greater proportionality improves the relationship between the coupling factor, k, and the optical transfer function.

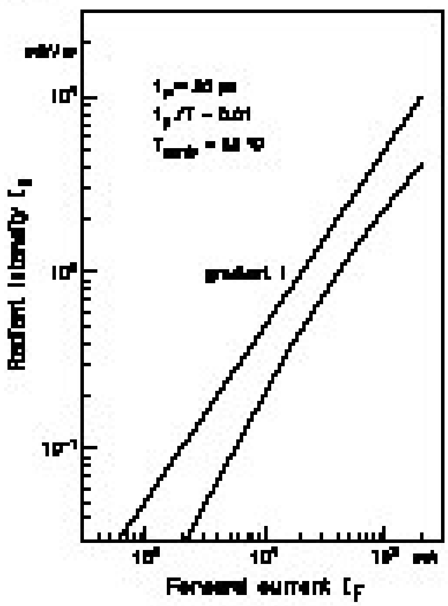


Figure 1. Radiant intensity, $I_e = f(I_F)$, of the IR transmitter

Coupling Factor, k

In the case of reflex couplers, the specification of the coupling factor is only useful by a defined reflection and distance. Its value is given as a percentage and refers here to the diffuse reflection (90%) of the white side of Kodak neutral card at the distance of the maximum light coupling. Apart from the transmitter current, I_F and the temperature, the coupling factor also depends on the distance from the reflecting surface and the frequency — that is, the speed of reflection change.

For all reflex sensors, the curve of the coupling factor as a function of the transmitter current, I_F, has a flat maximum at approximately 30 mA (figure 3). As shown in the figure, the curve of the coupling factor follows that of the current amplification, B, of the phototransistor. The influence of temperature on the coupling factor is relatively small and changes approximately –10% in the range of –10 to +70°C (figure 4). This fairly favorable temperature compensation is attributable to the opposing temperature coefficient of the IR diode and the phototransistor.

The maximum speed of a reflection change that is detectable by the sensor as a signal is dependent either on the switching times or the threshold frequency, f_c, of the component. The threshold frequency and the switching times of the reflex sensors TCRT1000, TCRT5000, and CNY70 are determined by the slowest component in the system — in this case the phototransistor. As usual, the threshold frequency, f_c, is defined as the frequency at which the value of the coupling factor has fallen by 3 dB (approximately 30%) of its initial value. As the frequency increases, $f > f_c$, the coupling factor decreases.

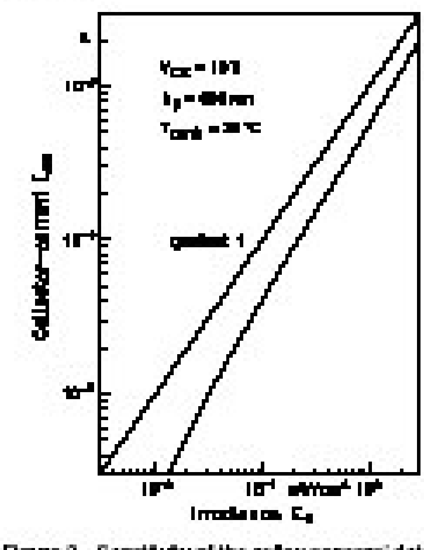


Figure 2. Sensitivity of the reflex sensors' detector

Vishay Telefunken

Application Examples, Circuits

The most important characteristics of the Vishay Telefunken reflex sensors are summarized in table 3. The task of this table is to give a quick comparison of data for choosing the right sensor for a given application.

Application Example with Dimensioning

With a simple application example, the dimensioning of the reflex sensor can be shown in the basic circuit with the aid of the component data and considering the boundary conditions of the application.

The reflex sensor is used for speed control. An aluminum disk with radial strips as markings fitted to the motor shaft forms the reflecting object and is located approximately 3 mm in front of the sensor. The sensor signal is sent to a logic gate for further processing.

Dimensioning is based on dc operation, due to the simplified circuitry.

The optimum transmitter current, I_F, for dc operation is between 20 and 40 mA. I_F = 20 mA is selected in this case.

As shown in figure 11, the coupling factor is at its maximum. In addition, the degradation (i.e. the reduction of the transmitted IR output with aging) is minimum for currents under 40 mA (< 10% for 10000 h) and the self healing is low due to the power loss (approximately 50 mW at 40 mA).

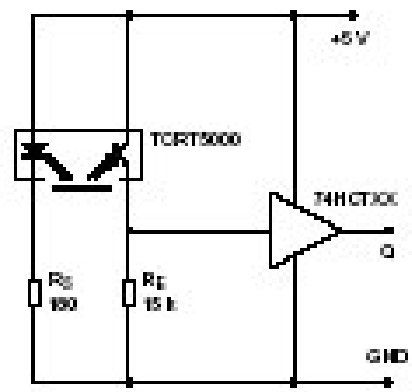


Figure 11. Reflex sensor - basic circuit

Table 3.

Parameter	Symbol	Reflex Sensor Type		
		CNY70	TCRT1000	TCRT5000
Distance of optimum coupling	A_0	0.3 mm	1 mm	2 mm
Distance of best resolution	A_r	0.2 mm	0.8 mm	1.5 mm
Coupling factor	k	5%	5%	6%
Switching distance (min.)	x_d	1.5 mm	0.7 mm	1.9 mm
Optimum working distance	X_{or}	0.2 to 3 mm	0.4 to 2.2 mm	0.2 to 6.5 mm
Operating range	A_{or}	9 mm	8 mm	> 20 mm

Table 4.

Application Data	
Aluminum disk	Diameter 50 mm, distance from the sensor 3 mm, markings printed on the aluminum
Markings	8 radial black stripes and 8 spacings, the width of the stripes and spacings in front of the sensor is approximately = 4 mm (in a diameter of 20 mm)
Motor speed	1000 to 3000 rpm
Temperature range	10 to 60°C
Ambient light	60 W fluorescent lamp, approximate distance 2 m
Power supply	5 V ± 5%
Position of the sensor	Position 1, sensor/ detector connecting line perpendicular to the strips

Special attention must also be made to the downstream logic gate. Only components with a low input offset current may be used. In the case of the TTL gate and the LS-TTL gate, the I_{LH} current can be applied to the sensor output in the low condition. At –1.6 mA or –400 µA, this is above the signal current of the sensor. A transistor or an operational amplifier should be connected at the output of the sensor when TTL or LS-TTL components are used. A gate from the 74HCTxx family is used.

According to the data sheet, its fault current I_{LH} is approximately 1 µA.

The expected collector current for the minimum and maximum reflection is now estimated.

According to the working diagram in figure 6a, it follows that when A = 3 mm

$I_c = 0.95 \times I_{cmax}$

I_{cmax} is determined from the coupling factor, k, for I_F = 10 mA.

$I_{cmax} = k \times I_F$

At I_F = 10 mA, the typical value

k = 2.8%

is obtained for k from figure 3.

However, this value applies to the Kodak neutral card or the reference surface. The coupling factor has a different value for the surfaces used (typewriting paper and black-fiber tip pen). The valid value for these material surfaces can be found in table 1:

k_1 = 94% × k = 4.7% for typing paper and

k_2 = 10% × k = 0.5% for black-tip pen (Edding)

Therefore: $I_{c1} = 0.95 \times k_1 \times I_F$ = 446.5 µA
$I_{c2} = 0.95 \times k_2 \times I_F$ = 47.5 µA

Temperature and aging reduce the collector current. They are therefore important to I_{c1} and are subtracted from it.

Figure 4 shows a change in the collector current of approximately 10% for 70°C. Another 10% is deducted from I_{c1} for aging

I_{c1} = 263 µA – (20% × 263 µA) = 357.2 µA

The fault current I_{cf} (from crosstalk and collector dark current) increases the signal current and is added to I_{c2}. Crosstalk with only a few nA for the TCRT5000 is ignored. However, the dark current can increase up to 1 µA at a temperature of 70°C and should be taken into account.

In addition, 1 µA, the fault current of the 74HCTxx gate, is also added

I_{c2} = 49.5 µA

The effect of the indirect incident ambient light can most easily be seen by comparing the radiant powers produced by the ambient light and the sensor's transmitter on 1 mm² of the reflecting surface. The ambient light is then taken into account as a percentage in accordance with the ratio of the powers.

From table 2:

E_e (0.5 m) = 40 µW/ cm² (dc + ac/ 2)
E_e (2 m) = E_e(0.5 m) × (0.5/ 2)²

(Square of the distance law)

E_e (2 m) = 2.5 µW/ cm²
ϕ_{el} = 0.025 µW

The radiant power (ϕ_{el} = 0.025 µW) therefore falls on 1 mm².

When I_F = 10 mA, the sensor's transmitter has the radiant intensity:

$$I_e = \frac{\Phi_e}{\Omega} = 0.25\ \text{W/sr}$$

(see figure 1)

The solid angle for 1 mm² surface at a distance of 3 mm is

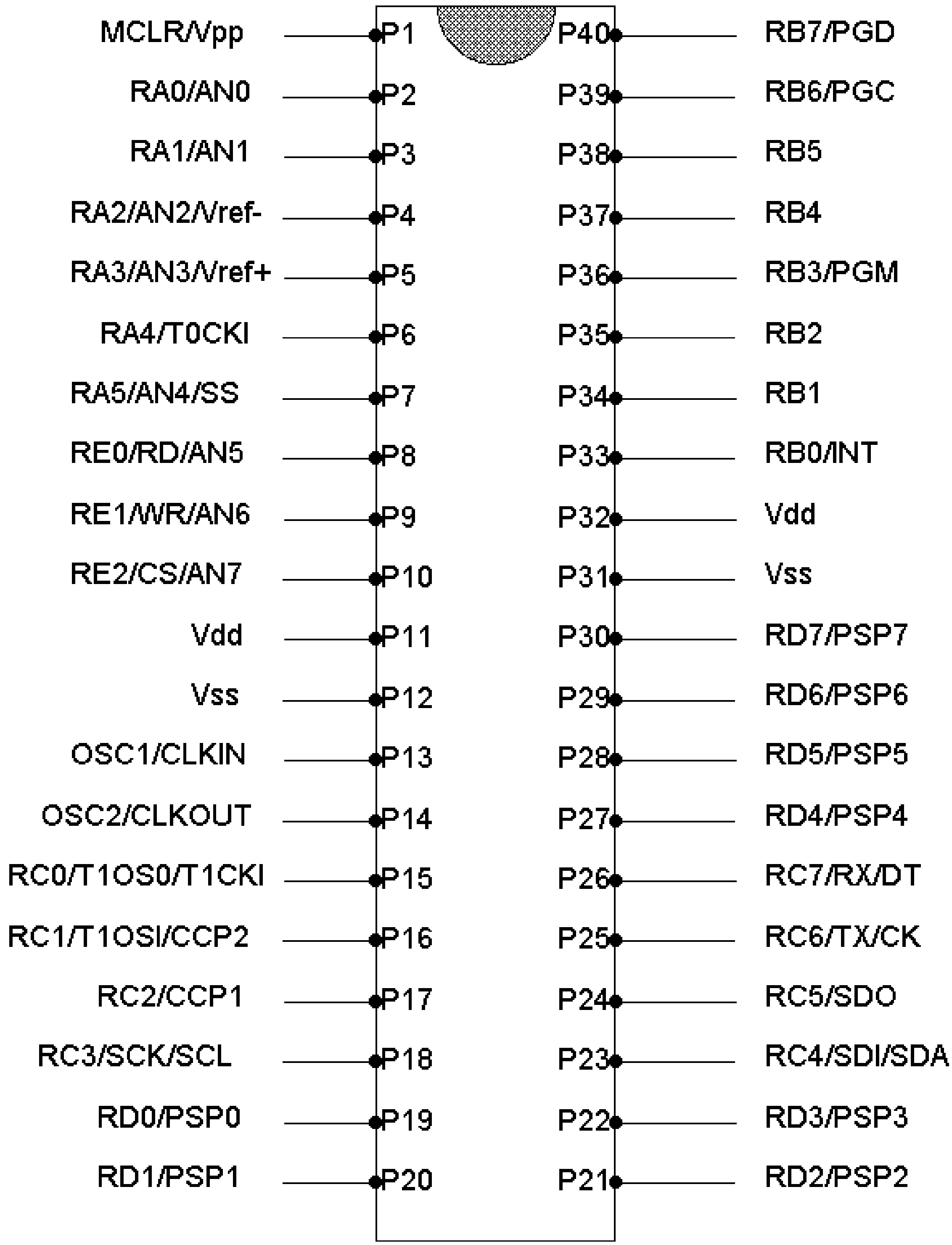
$$\Omega = \frac{1\ \text{mm}^2}{(3\ \text{mm})^2} = \frac{1}{9}\text{sr}$$

It therefore follows for the radiant power that:

$\Phi_e = I_e \times \Omega$ = ca. 27.8 mW

The power of 0.025 µW produced by the ambient light is therefore negligibly low compared with the corresponding power (approximately 28 µW) of the transmitter.

The currents I_{c1}, I_{c2} would result in full reflecting surfaces, that is, if the sensor's visual field only measures white or black typing paper. However, this is not the case. The reflecting surfaces exist in the form of stripes.



Para información detalla del funcionamiento del microcontrolador 16F74, 16F877, referirse a la pagina de MICROCHIP® , http://www.michochip.com/