

Elektrohidraulički robotski manipulator

Janković, Ivan

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SVEUČILIŠTE U ZAGREBU
FAKULTET STROJARSTVA I BRODOGRADNJE

DIPLOMSKI RAD

Ivan Janković

Zagreb, 2015.

SVEUČILIŠTE U ZAGREBU
FAKULTET STROJARSTVA I BRODOGRADNJE

DIPLOMSKI RAD

Mentor:

Prof. dr. sc. Željko Šitum, dipl. ing.

Student:

Ivan Janković

Zagreb, 2015.

Izjavljujem da sam ovaj rad izradio samostalno koristeći stečena znanja tijekom studija i navedenu literaturu.

Zahvaljujem profesoru, mentoru dr. sc. Željku Šitumu i Ivici Ivanicu što su mi pomogli prilikom izrade ovog rada, kao i tvrtki Rasco d.o.o. na susretljivosti i pomoći.

Ivan Janković



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Student: **IVAN JANKOVIĆ** Mat. br.: 0035185242

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Opis zadatka:

U suvremenim industrijskim procesima često su potrebni manipulatori koji mogu prenositi radne predmete velikih masa uz visoku preciznost upravljanja gibanjem i veliku fleksibilnost radnih operacija (npr. sklapanje teških dijelova na automatiziranim montažnim linijama, zadaci posluživanja velikih obradnih strojeva i dr.). U takvim zadacima manipulatori s električnim pogonom imaju ograničen iznos nosivosti za koje se mogu koristiti, pa primjena hidraulički pogonjenih manipulatora može uspješno odgovoriti postavljenim zahtjevima. Elektrohidraulički sustavi daju povoljne karakteristike automatiziranim industrijskim pogonima, jer povezuju mogućnosti ostvarenja velikih snaga hidrauličkim putem i jednostavnu obradu i prijenos upravljačkih signala električnim komponentama. U cilju istraživanja kao i edukacije studenata pokrenut je postupak projektiranja i izrade prototipa robotskog manipulatora s hidrauličkim pogonom za veće nosivosti radnih predmeta.

U radu je potrebno:

- Razmotriti različite varijante izvedbi elektrohidrauličkih robotskih manipulatora i objasniti njihove radne značajke.
- Opisati glavne komponente pogonskog, mehaničkog, mjernog i upravljačkog dijela sustava i dati njihove tehničke specifikacije.
- Opisati regulaciju rada crpke impulsom tlaka (tzv. *load sensing system*) gdje je raspodjela snage uvjetovana kontrolom opterećenja.
- Demonstrirati ručni način rada manipulatora i dati smjernice za automatsko upravljanje sustavom.

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Predsjednik Povjerenstva:

Prof. dr. sc.  Franjo Cajner

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1. Hidraulička shema elektorhidrauličkog robotskog manipulatora
2. Nosač joysticka

POPIS OZNAKA

Oznaka	Jedinica	Opis
Q_p	m^3/s	Protok pumpe
V_p	cm^3/okr	Volumen pumpe po okretaju
n	min^{-1}	Broj okretaja pumpe
P_{EM}	W	Snaga elektromotora
Δp	Pa	Razlika tlakova
η_{uk}		Ukupni koeficijent korisnog djelovanja
η_{vol}		Volumenski koeficijent korisnog djelovanja
η_{meh}		Mehanički koeficijent korisnog djelovanja
ω	rad/s	Kutna brzina
i		Prijenosni omjer
D_c	mm	Promjer dvoradnog cilindra
Q_1	m^3/s	Protok kroz dvoradni cilindar
A_1	m^2	Površina dvoradnog cilindra kod izvlačenja
A_2	m^2	Površina dvoradnog cilindra kod uvlačenja
v_{i1}	m/s	Brzina izvlačenja dvoradnog cilindra
F	N	Sila kod izvlačenja dvoradnog cilindra
p	Pa	Tlak
D	mm	Promjer cilindra
d	mm	Promjer klipnjače
v_{u1}	m/s	Brzina uvlačenja dvoradnog cilindra
Q_2	m^3/s	Protok kroz teleskopski cilindar
A_3	m^2	Površina teleskopskog cilindra kod izvlačenja
A_4	m^2	Površina teleskopskog cilindra kod uvlačenja
v_{i2}	m/s	Brzina izvlačenja teleskopskog cilindra
LS		Loadsensing pumpa
PVBZ		Proporcionalni ventil osnovni modul bez propuštanja
PVEH		Proporcionalni ventil električni pogon s 4-9% histereze
PVM		Proporcionalni ventil ručna kontrola, ručica
PVLA		Ventil za sprječavanje kavitacije
PVP		Proporcionalni ventil strana modula, uvala;rukavac; utikač
PVB		Proporcionalni ventil osnovni model, ventil kriška
PVBS		Proporcionalni ventil osnovni model, klip
PVE		Proporcionalni ventil električni pogon
PVG		Proporcionalni ventil grupa, multi sekcija ventila

SAŽETAK

Elektrohidraulički robotski manipulator (EHROM) je izveden u elektro-hidrauličkoj konfiguraciji: elektromotorom pokretana LS-pumpa i izvršni članovi (hidromotor za prvi rotacijski zglob i dva hidraulička cilindra za osiguravanje tražene nosivosti). LS regulacija rada pumpe, odnosno regulacija rada pumpe impulsom tlaka (eng. Load sensing- LS) ima za zadatak prilagođavanje tlaka i protoka pumpe trenutnim zahtjevima izvršnih elemenata. Upravljanje je izvršeno na tri načina, mehanički preko poluga na razvodniku, pomoću joysticka te upravljanjem preko računala. EHROM je izrađen u potpunosti i koristi se u obrazovne svrhe.

Ključne riječi: Manipulator; Hidraulika; Upravljanje impulsom tlaka(LS); Hidraulički sustavi; Upravljanje

SUMMARY

Electrohydraulic robotic manipulator (EHROM) is designed in electro-hydraulic configuration - electric motor driven by LS-pump and executive components (hydraulic motor for the first rotary joint and two hydraulic cylinders to provide the required capacity). LS regulation of a pump, i.e. regulation of the pump pulse pressure (Load sensing - LS) has the task of adjusting the pressure and flow of the pump to current requirements by actuators. Control is done in three ways - mechanical lever on hydraulic valve, joystick and by the ability to control it with computer. EHROM is made in full and used for educational purposes.

Key words: Manipulator; Hydraulics; Load Sensing; Hydraulic system; Control

1. UVOD

U današnje se vrijeme radi sve veće potrebe u industriji i ostalim pogonima koriste se manipulatori, koji služe za obavljanje različitih zadataka kao što su zavarivanje, posluživanje strojeva, montaža nekih dijelova, manipulacija teških i većih obradaka te za završna mjerenja i kontrolu da bi svaki proizvod bio jednak i izrađen u granicama tolerancija. Manipulatori danas uvelike zamjenjuju ljude u mnogim poslovima zbog povećanja kvalitete proizvoda, preciznosti, umora, radnih operacija koje su izvan fizičkih mogućnosti čovjeka te iz ekonomskih razloga (povećanje produktivnosti, povećanje proizvodnje i uštede energije). Zbog njihove današnje raširenosti i načina upravljanja potrebni su i ljudi koji će raditi s manipulatorima. Zbog toga se danas manipulatori koriste i u obrazovne svrhe, kako bi ljudi naučili na koji se način upravlja i programira manipulator. Kroz razvoj industrije potreba za manipulatorom je bila sve veća pa je tako počeo i njihov razvoj. Danas postoji mnogo manipulatora različitih proizvođača koji se masovno koriste u industriji.



Slika 1. Robotska ruka [1]

2. OSNOVNE STRUKTURE MANIPULATORA

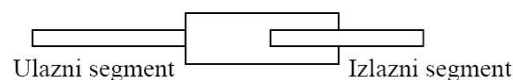
Manipulatori danas imaju različite strukture. Svaka struktura ima svoje značajke te se po tome manipulatori razlikuju jedan od drugog. Svaki manipulator u industriji pričvršćen je za podlogu te se sastoji od osnovnih dijelova. Osnovni dijelovi su: tijelo i ruka manipulatora koja na kraju sadrži zglob ili prihvatnicu kojom se hvata objekt.

2.1. Glavni dijelovi manipulatora

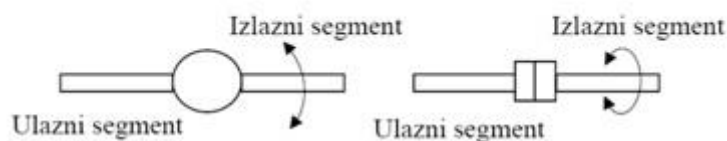
Svaki manipulator se sastoji od glavnih dijelova uz pomoć kojih ostvaruje željeni rad. Glavni dijelovi manipulatora su:

1. Mehanička struktura: niz segmenata povezanih zglobovima koji mogu biti:

- 1.1 Translacijski (T) – translacija je gibanje kada se dva dijela robota, međusobno povezana, gibaju tako da jedan ulazi u drugi[3].



- 1.2 Rotacijski (R) – rotacija je gibanje kada se dijelovi okreću oko zajedničkog zgloba.

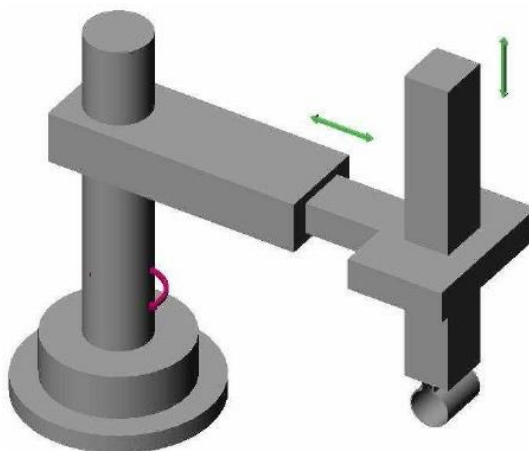


2. Pogon manipulatora: postiže postavljanje manipulatora u željeni položaj. Moguće su različite izvedbe pogona kao što su električni, hidraulički i pneumatski.
3. Upravljanje: računalo ili joystick.
4. Senzori: manipulatoru mjeri trenutni položaj.

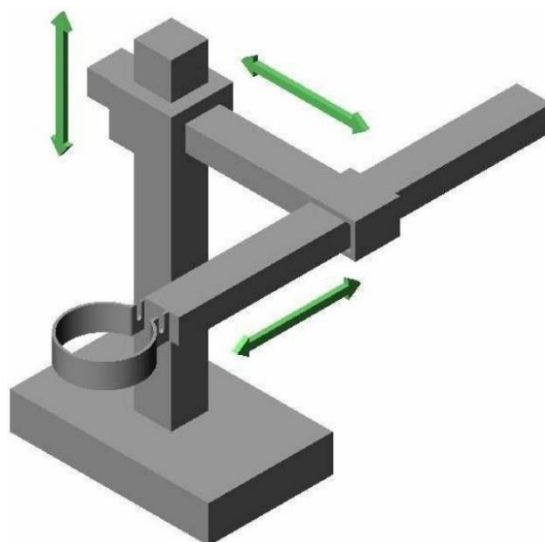
2.2. Najčešće strukture manipulatora

U nastavku su prikazane najčešće strukture manipulatora u praksi. Svaka struktura ima svoje značajke te na taj način se odabire odgovarajuća struktura ovisno koje su potreba manipulatora.

1. Cilindrična struktura: RTT



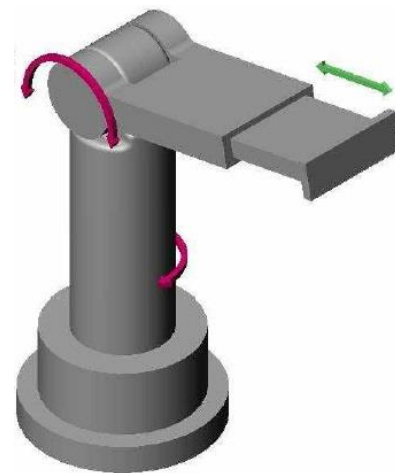
2. Kartezijeva struktura: TTT



3. Rotacijska struktura: RRR



4. Sferna struktura: RRT



5. SCARA struktura: RR RT



U suvremenim industrijskim procesima često su potrebni manipulatori koji mogu prenositi radne predmete velikih masa uz visoku preciznost upravljanja gibanjem i veliku fleksibilnost radnih operacija (npr. sklapanje teških dijelova na automatiziranim montažnim linijama, zadaci posluživanja velikih obradnih strojeva i dr.). U takvim zadacima manipulatori s električnim pogonom imaju ograničen iznos nosivosti za koje se mogu koristiti pa primjena hidraulički pogonjenih manipulatora može uspješno odgovoriti postavljenim zahtjevima. Elektrohidraulički sustavi daju povoljne karakteristike automatiziranim industrijskim pogonima jer povezuju mogućnosti ostvarenja velikih snaga hidrauličkim putem i jednostavnu obradu i prijenos upravljačkih signala električnim komponentama.

Za daljnje razmatranje odabrana je sferna struktura (RRT) koja se sastoji od dva rotacijska zgloba i jednog translacijskog zgloba.

Navedena struktura manipulatora je rjeđa u praksi, no u ovom slučaju odabrana je zbog toga kako bismo prikazali različite izvršne elemente na jednom uređaju (manipulatoru). Odabrani izvršni elementi su: hidromotor pomoću kojeg se ostvaruje rotacija, hidraulički cilindar te dvoradni teleskopski cilindar pomoću kojeg se ostvaruje translacija. Struktura ima dobru fleksibilnost i mali moment inercije. Primjer izvedbe sferne strukture je manipulator koji je smješten na kamionima i dostavnim vozilima [Slika 2].



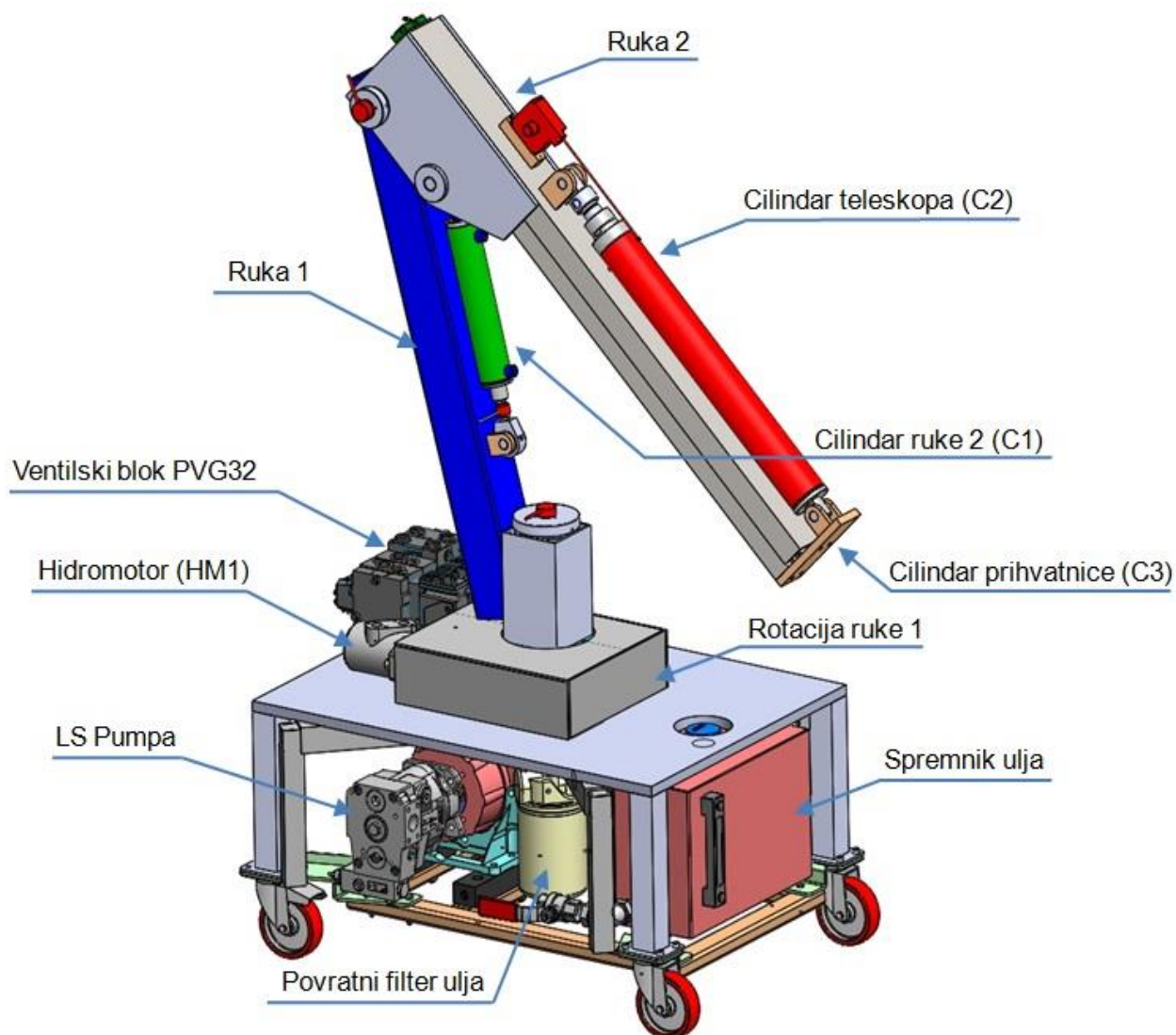
Slika 2. Manipulator Palfinger PC1500 [6]

Hidraulika je do unazad nekoliko godina bila zapostavljena u školama i tvornicama, čak i više od pneumatike. Pneumatika je nešto jednostavnija i primjenjivana je više u industrijskim pogonima, strojevima i napravama. Suvremena hidraulika traži dodatna znanja regulacije i elektronike (elektrohidraulika). U područjima velikih sila, brzina i ubrzanja, malih jednoličnih kretanja te neograničenih međupoložaja između krajnjih položaja hidraulika je nezamjenjiva.

Danas se sve više koristi elektrohidraulika koja je upravljana pomoću elektronike te time dobivamo sve veću mogućnost pozicioniranja predmeta. Elektrohidraulika nalazi najširu primjenu u svim tipovima radnih strojeva i vozila, poljoprivredi, ratnoj tehnici itd. Jedini nedostaci hidraulike su: potreba za povratnim vodovima, relativno nečist pogon te skupi uređaji i elementi.

3. GLAVNE KOMPONENTE MANIPULATORA (EHROM)

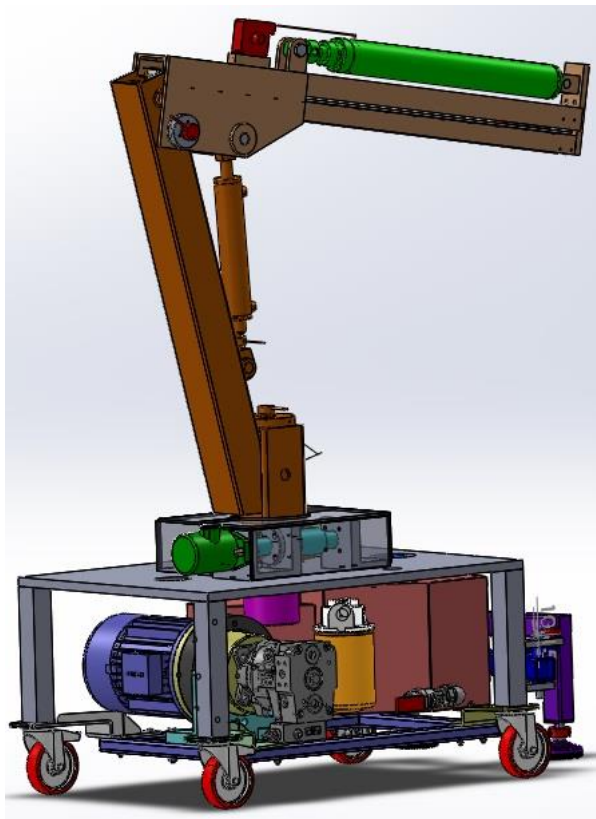
Na [Slika 3] prikazane su glavne komponente manipulatora. Navedene komponente dio su mehaničkog, pogonskog, upravljačkog i mjernog sustava.



Slika 3. Glavne komponente elektrohidrauličkog robotskog manipulatora – EHROM-a

3.1. Mehaničke komponente

Kako je navedeno u prethodnom poglavlju, manipulator ima sfernu strukturu s jednom translacijskom osi i dvije rotacijske [Slika 4]. Konstrukcija manipulatora se nalazi na osnovnoj ploči koja je oslonjena na noge s kotačima koji omogućavaju mobilnost. Za radni položaj predviđeno je oslanjanje na podesive noge s čvrstim osloncima.



Slika 4. Elektrohidraulički robotski manipulator – EHROM

Manipulator je podijeljen na tri dijela:

1. Osnovna ploča s nogama, središnjim stupom i hidromotorom s pužnim prijenosom.
2. Stupna konstrukcija s pužnim kolom i podiznim cilindrom.
3. Translacijska konzola s teleskopskim cilindrom i prihvatnicom.

Navedeni elementi povezani su međusobno u dva rotacijska zgloba. Treći stupanj slobode je translacija pokretnog dijela konzole.

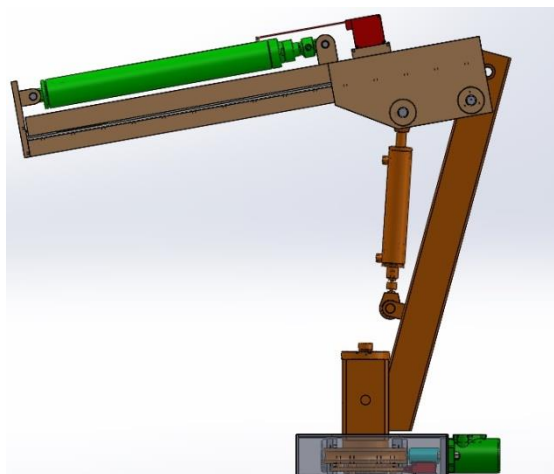
Manipulator je zamišljen kao nastavno pomagalo te je glavna konstrukcijska ideja bila vidljivost svih elemenata koji sudjeluju, kako bi ih studenti mogli vidjeti u samom radu.

3.1.1. Rotacija postolja robota

Prvi zglob je rotacija stupne konstrukcije oko središnje osovine. Uležištenje je izvedeno u aksijalnom i radijalnom smjeru. Aksijalno je ugrađen aksijalni kuglični ležaj FAG 51116. Radijalno uležištenje je izvedeno s dva klizna ležaja od bronce koji kližu po osovini.

3.1.2. Rotacija translacijske konzole oko osovine na stupu

Drugi stupanj slobode je rotacija translacijske konzole oko osovine na stupu. Rotaciju omogućuje dvoradni hidraulički cilindar koji je s donje strane učvršćen na stupnu konstrukciju, a gore na nepokretni dio konzole, [Slika 5].



Slika 5. Rotacija translacijske konzole

Kut rotacije iznosi 82° , što omogućava hvatanje nekog elementa prihvatnicom s poda, a zatim podizanje na visinu 2480 mm.

3.1.3. Translacija konzole

Treći stupanj slobode je translacija pokretnog dijela konzole koju omogućuje dvoradni teleskopski hidraulički cilindar. Zglob je izveden pomoću vodilice pravokutnog presjeka s kugličnim vođenjem. Ovakve vodilice koriste se na obradnim centrima, alatnim strojevima, automatskoj opremi. Vodilica HGH35HA[Slika 6] omogućuje glatko i ravnomjerno gibanje pomičnog dijela konzole. Sastoji se od statičnog dijela (vagona) i pomičnog dijela (tračnice) dužine 1,2 m.



Slika 6. Linearna vodilica [8]

Prilog 1: Linearna vodilica HGH 35 HA

3.2. Komponente pogonskog dijela manipulatora

Pogon manipulatora sastoji se od pumpe, elektromotora, ostalih dijelova hidroagregata, hidromotora, podiznog i teleskopskog hidrauličkog cilindra. U prilogu je hidraulička shema pogonskog dijela manipulatora.

3.2.1. Proračun pogonskog agregata

3.2.1.1. Pumpa

Za pogon manipulatora odabrana je klipna pumpa tvrtke Parker oznake PV023R1K1T1NMFC s LS (eng. Loadsensing) funkcijom.

Karakteristike pumpe:

- volumen po okretaju: $23 \text{ cm}^3/\text{okr}$
- protok pri 1500 o/min: 34.5 l/min

3.2.1.2. Proračun elektromotora

Protok pumpe pri 1440 o/min iznosi:

$$Q_p = V_p \cdot n = 23 \cdot 1440 = 33120 \frac{\text{cm}^3}{\text{min}} = \mathbf{33.12 \text{ l/min}}$$

Snaga elektromotora računa se prema sljedećem izrazu:

$$\Delta p = 100 \text{ bar}$$

$$P_{EM} = \frac{Q_p \cdot \Delta p}{600 \cdot \eta_{uk}} = \frac{Q_p \cdot \Delta p}{600 \cdot \eta_{vol} \cdot \eta_{meh}} = \mathbf{6.11 \text{ kW}}$$

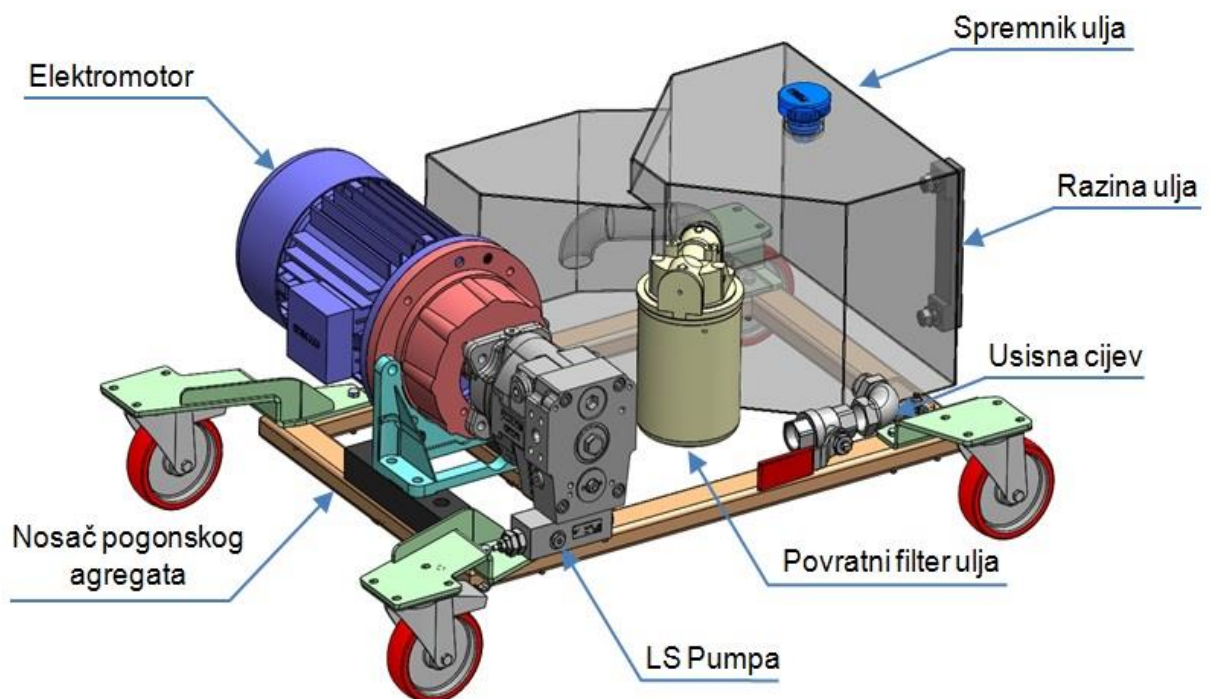
$$\eta_{vol} = 0.95$$

$$\eta_{meh} = 0.95$$

Zbog konstrukcijskih razloga (nedostatak mjesta) uzet je elektromotor snage **5.5 kW** tvrtke Končar.

3.2.2. Hidroagregat

Hidroagregat je pogonska cjelina sastavljena od elektromotora snage 5.5 kW, LS pumpe PV32, bloka sa sigurnosnim ventilom i spremnikom ulja. Cijeli hidroagregat je smješten ispod osnovne ploče da bi manipulator bio kompaktniji.



Slika 7. Komponente hidroagregata

3.2.3. Elektromotor

Prema proračunu za elektromotor kao pogon pumpe izabran je elektromotor snage **5,5 kW**. To je trofazni kavezni asinkroni motor, a elektromotor ima oznaku: **5AZH 112M-4**. U nastavku slijedi pojašnjenje navedene oznake za elektromotor.



Slika 8. Oznaka elektromotora [9]

Tablica 1. Oznake i karakteristike elektromotora [9]

2p=4		1500 min ⁻¹			400V / 50Hz						1800 min ⁻¹ / 440V / 60Hz			
P (kW)	Motor type	n (min ⁻¹)	η (%)	cos φ	I _n (A)	$\frac{I_k}{I_n}$	M _n (Nm)	$\frac{M_k}{M_n}$	$\frac{M_{max}}{M_n}$	J (kgm ²)	m (kg)	P (kW)	n (min ⁻¹)	I _n (A)
3	5AZ 100LB-4	1410	82.5	0.82	6.5	5.7	20	2.5	2.8	0,0070838	24	3.4	1690	6.5
3.5	5AZH 100LB-4	1410	82	0.77	8.0	5.8	25	2.7	2.9	0,0070838	25	4.0	1690	8
4	5AZ 112M-4	1435	84.5	0.80	8.5	7	27	2.8	3.1	0,0121970	33	4.5	1720	8.5
5.5	5AZH 112M-4	1410	82	0.78	12.5	5.5	35	2.7	3.0	0,0121970	33	6.2	1690	12.5



Slika 9. Elektromotor 5AZH 112M-4

Prilog 2: Končar elektromotori

3.2.4. Load sensing pumpa (LS pumpa)

Za pogon manipulatora odabrana je klipna pumpa tvrtke Parker oznake PV023R1K1T1NMFC s LS (eng. Loadsensing) funkcijom. Svaka pumpa ima svoju oznaku po čemu se razlikuje od drugih pumpi. Prilog 3: Parker pumpa.



Slika 10. LS pumpa [10]

Ova pumpa odabrana je prema potrebnom protoku (glavni potrošač je hidromotor), a LS izvedba zbog energetske učinkovitosti sustava u kombinaciji s proporcionalnim razvodnikom PVG 32 s LS povratnom vezom.

U [Tablica 2] prikazani su tehnički podaci za navedenu pumpu.

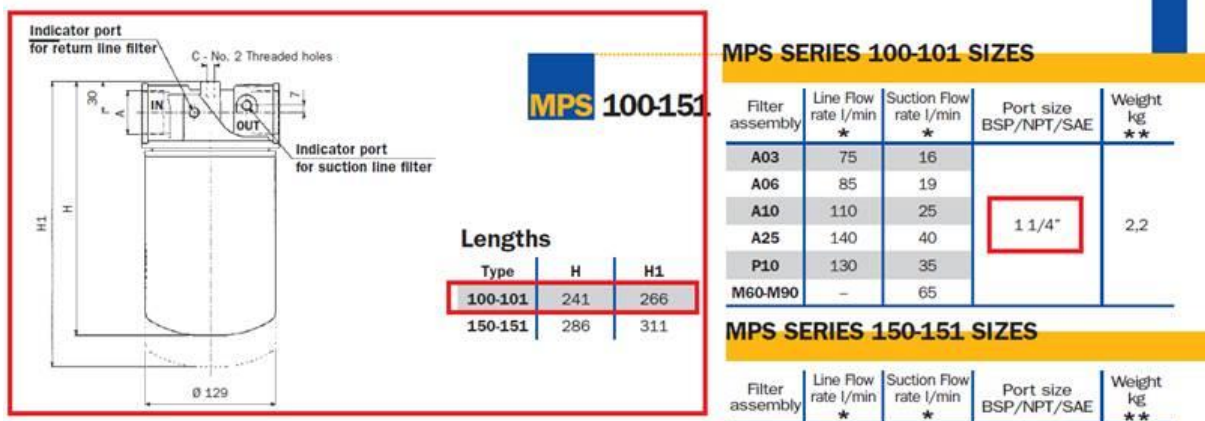
Tablica 2. Tehnički podaci za pumpu

	PV016	PV020	PV023	PV028	PV032	PV040
Frame size	1	1	1	1	2	2
Max. Displacement [cm ³ /rev.]	16	20	23	28	32	40
Output flow at 1500 rpm [l/min]	24	30	34,5	42	48	60
Nominal pressure pN [bar]	350	350	350	350	350	350
Max. pressure pmax at 20% working cycle [bar]	420	420	420	420	420	420
Case drain pressure, continuous [bar]	0,5	0,5	0,5	0,5	0,5	0,5
Case drain pressure, max. peak [bar]						
Min. Inlet pressure, abs. [bar]	0,8	0,8	0,8	0,8	0,8	0,8
Max. Inlet pressure [bar]	16	16	16	16	16	16
Input power at 1500 rpm and 350 bar [kW]	15,5	19,5	22,5	27,5	31	39
Max speed at 1 bar inlet pressure [rpm]	3000	3000	3000	3000	2800	2800
Moment of inertia [kgm ²]	0,0017	0,0017	0,0017	0,0017	0,0043	0,0043
Weight [kg]	19	19	19	19	30	30

3.2.5. Povratni filter ulja

Kao povratni filter ulja izabran je filter MPS 100. Specifikacije filtera dane su u Prilogu 4.

Tablica 3. Povratni filter ulja



3.2.6. Elektroormar

Elektroormar je također dio osnovne opreme manipulatora. U njemu su smještene sve električne komponente sustava koje služe za upravljanje manipulatorom.



Slika 11. Elektroormar sa pripadajućim sklopkama

3.2.7. Hidromotor

Za odabir hidromotora potrebno je odabrati način pogona prve osi. Kao rješenje odabran je pužni prijenos s pužnim vijkom i kolom.

3.2.7.1. Pužni prijenos

Zupčanički par odabran je prema unutrašnjem promjeru zupčastog vijenca koji je bilo moguće ugraditi na stup oko kojeg se okreće manipulator. Odabrana je vanjska veličina 215 mm prema DIN 3975 / 3976, a za osni razmak 125 mm. S pužnim kolom uparen je pužni vijak promjera 50 mm. Odabran je modul $m=4$ i prijenosni omjer $i=50:1$.

Podaci zupčastog vijenca:

- prijenosni omjer: $i=50:1$
- modul: $m=4$
- broj zubi: $z=50$
- zahvatni promjer: $D_e=212$ mm
- materijal: SL 25

Podaci pužnog vijka:

- prijenosni omjer: $i=50:1$
- modul: $m=4$
- broj zubi: $z=1$
- zahvatni promjer: $d_m=58$ mm
- materijal: Č 4320, cementirano: 0,6-0,8 mm; kaljeno 58-60 HRC

Prilog 5: Pužni vijak i kolo

Pužni vijak je uležišten u dva aksijalno radijalna ležaja FAG 7205-B

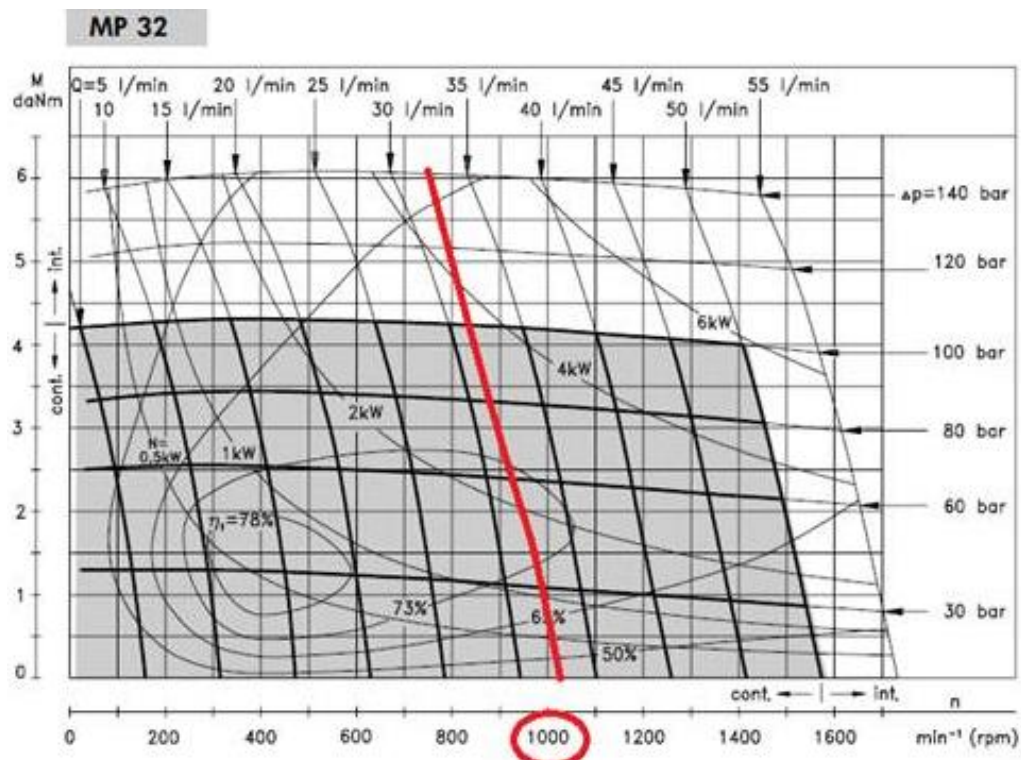
Prilog 6: FAG ležajevi

3.2.7.2. Izbor hidromotora

- projektirana kutna brzina: $\omega = 2 \text{ rad/s}$, $n \approx 20 \text{ o/min}$
- prijenosni omjer: $i = 50:1$
- potreban broj okretaja hidromotora: $n = 20 \cdot 50 = 1000 \text{ o/min}$

Prema [Tablica 4] izabran je **hidromotor MP32**

Tablica 4. Karakteristike hidromotora MP32



Dijagram prikazuje karakteristike hidromotora MP32, kako pumpa ima protok 34,5 l/min odabran je hidromotor koji ima protok 32 l/min na 1000 okretaja kako bi smo ostvarili potrebnu kutnu brzinu od 2 rad/s.

Karakteristike hidromotora MP32:

- volumen: $32 \text{ cm}^3/\text{okr}$
- maksimalna brzina: 1560 o/min
- maksimalni okretni moment: 43 Nm
- maksimalni radni tlak: 100 bar
- maksimalni protok: 50 l/min



Slika 12. Hidromotor MP32

Prilog 7: Hidromotor MP32

3.2.8. Hidraulički podizni dvoradni cilindar

Proračun u nastavku pokazuje brzinu izvlačenja/uvlačenja cilindra te sile koje se javljaju prilikom navedenih radnji.

Veličina hidrauličkog dvoradnog cilindra: $D_c = 50 \text{ mm}$

Karakteristike dvoradnog hidrauličkog cilindra [Slika 13]:

- cijev: $\emptyset 50 / \emptyset 60$
- klipnjača: $\emptyset 25$
- hod: 210 mm

Brzina izvlačenja dvoradnog hidrauličkog cilindra:

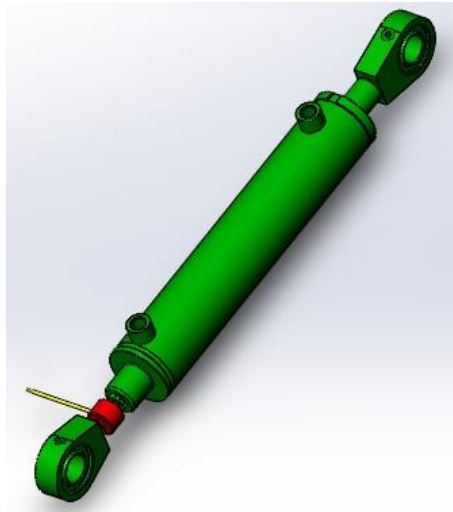
$$Q_1 = 10 \text{ l/min} = 1.666667 \cdot 10^{-4} \text{ m}^3/\text{s}$$
$$A_1 = \frac{D^2 \cdot \pi}{4} = \frac{0.050^2 \cdot \pi}{4} = 1.962 \cdot 10^{-3} \text{ m}^2$$
$$v_{i1} = \frac{Q_1}{A_1} = \frac{1.666667 \cdot 10^{-4}}{1.962 \cdot 10^{-3}} = \mathbf{0.0848 \text{ m/s} = 84.80 \text{ mm/s}}$$

Sila kod izvlačenja dvoradnog hidrauličkog cilindra:

$$F = p \cdot A_1 = 100 \cdot 10^5 \cdot 1.962 \cdot 10^{-3} = \mathbf{19.6 \text{ kN}}$$

Brzina uvlačenja dvoradnog hidrauličkog cilindra:

$$Q_1 = 10 \text{ l/min} = 1.666667 \cdot 10^{-4} \text{ m}^3/\text{s}$$
$$A_2 = \frac{(D^2 - d^2) \cdot \pi}{4} = \frac{(0.050^2 - 0.025^2) \cdot \pi}{4} = 1.471 \cdot 10^{-3} \text{ m}^2$$
$$v_{u1} = \frac{Q_1}{A_2} = \frac{1.666667 \cdot 10^{-4}}{1.471 \cdot 10^{-3}} = \mathbf{0.1131 \text{ m/s} = 113.10 \text{ mm/s}}$$



Slika 13. Hidraulički podizni dvoradni cilindar

3.2.9. Teleskopski dvoradni hidraulički cilindar

Karakteristike dvoradnog teleskopskog hidrauličkog cilindra [Slika 14]:

- vanjska cijev: Ø63H8 / Ø75
- srednja cijev: Ø45H8 / Ø55f7
- unutarnja cijev: Ø25 / Ø35f7
- hod: 1000 mm

Brzina izvlačenja teleskopskog cilindra 1. dio

$$Q_2 = 10 \text{ l/min} = 1.666667 \cdot 10^{-4} \text{ m}^3/\text{s}$$

$$A_3 = \frac{D^2 \cdot \pi}{4} = \frac{0.063^2 \cdot \pi}{4} = 3.11 \cdot 10^{-3} \text{ m}^2$$

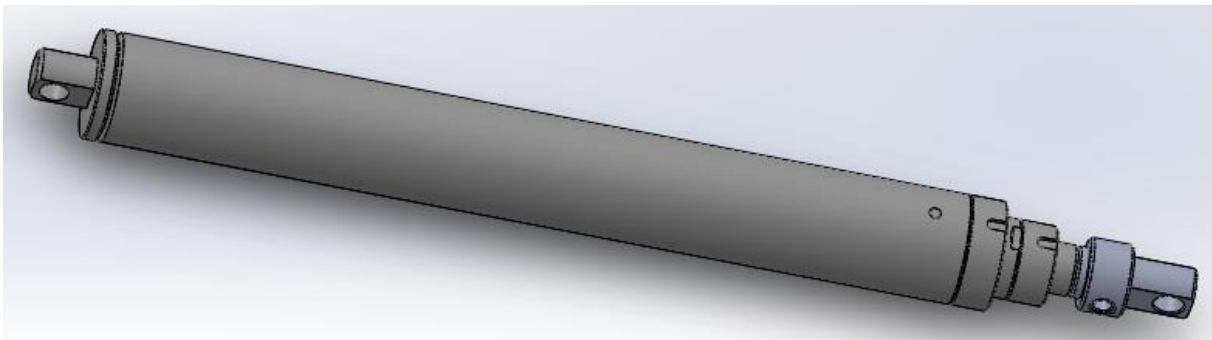
$$v_{i1} = \frac{Q_2}{A_3} = \frac{1.666667 \cdot 10^{-4}}{1.471 \cdot 10^{-3}} = 0.0535 \text{ m/s} = 53 \text{ mm/s}$$

Brzina izvlačenja teleskopskog cilindra 2.dio:

$$Q_2 = 10 \text{ l/min} = 1.666667 \cdot 10^{-4} \text{ m}^3/\text{s}$$

$$A_4 = \frac{D^2 \cdot \pi}{4} = \frac{0.045^2 \cdot \pi}{4} = 1.589 \cdot 10^{-3} \text{ m}^2$$

$$v_{i2} = \frac{Q_2}{A_4} = \frac{1.666667 \cdot 10^{-4}}{1.471 \cdot 10^{-3}} = \mathbf{0.1047 \text{ m/s} = 104.70 \text{ mm/s}}$$



Slika 14. Dvoradni teleskopski hidraulički cilindar

3.3. Komponente upravljačkog dijela manipulatora

Upravljački dio manipulatora sastoji se od razvodnog ventila i upravljačke ručice - joysticka, a predviđena je i mogućnost spajanja manipulatora na računalo. Također, razvodnik ima i mogućnost upravljanja preko mehaničkih ručica.

3.3.1. Razvodni ventil

Da bismo simultano mogli upravljati sa sve 3 osi odabran je proporcionalni razvodnik Danfoss PVG32 [Slika 15]. Razvodnik je sastavljen od 4 razvodna segmenta te priključne i završne ploče. Razvodnikom je moguće upravljati pomoću poluga i daljinski pomoću upravljača JoystickProf-1.

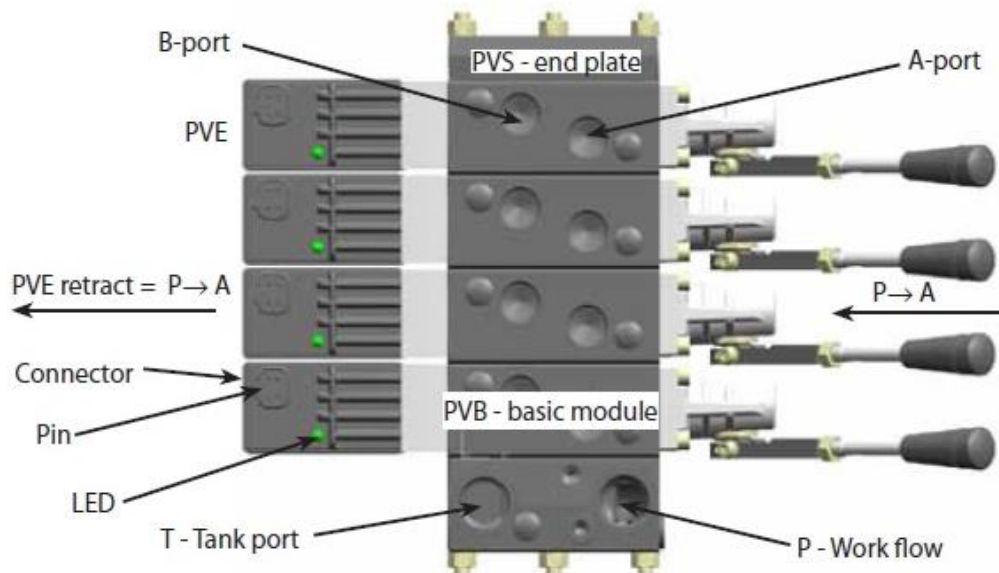


Slika 15. Razvodni ventil PVG32

Prednosti kod ovakvih razvodnika su:

- protok ulja u nekom segmentu neovisan je o tlaku u tom segmentu, kao i u susjednim segmentima,
- dobra svojstva regulacije, lagan i kompaktne konstrukcije,
- svaki segment može imati različiti protok zavisno od iznosa upravljačkog signala na proporcionalnom ventilu..

Na [Slika 16] dana je shema razvodnika PVG32. Prilikom spajanja razvodnika u pogon shema nam je vrlo bitna.



Slika 16. Shema razvodnika

Prilikom izbora razvodnika moramo točno znati naše zahtjeve i tako odabrati razvodnik. Razvodnik se može sklopiti po zahtjevima korisnika. Tvrtka Danfoss na svojim stranicama ima tablicu koju treba ispuniti prije kupovine određenog razvodnika. U [Tablica 5] je opisano kako izgleda razvodnik i prodavatelj ima točan uvid u naše zahtjeve. U tablici je naveden i primjer popunjavanja tablice za izabrani razvodnik. Svaka šifra na odgovarajućem mjestu ima određen dio prema katalogu. Oznake kod razvodnika dane su u prilogu.

Prilog 8: Razvodnik PVG32

Tablica 5. Specifikacija razvodnika PVG32

Customer: FSB		Application: KRAN		PVG PN		8122014						
				Subsidiary / Dealer:				BIBUS Zagreb d.o.o.				
Function		A - Port		0		B - Port						
↓		↓		p ⁿ 160 bar		↓						
PVBZ 10 l/min PVEH	a	157B3171	PVM	157B6252	PVBZ	157B9400	PVBS	16	157B4033	PVEH	a	
	b	157B2001	PVLA						157B2001	PVLA	b	
	b			LS _A	bar	LS _B	bar				b	
40 l/min PVEH	a	157B3171	PVM	2	157B6210	PVB	157B7002	PVBS	16	157B4033	PVEH	a
	b	157B2001	PVLA						157B2001	PVLA	b	
	b			LS _A	bar	LS _B	bar				b	
10 l/min PVEH	a	157B3171	PVM	3	157B6210	PVB	157B7000	PVBS	16	157B4033	PVEH	a
	b	157B2001	PVLA						157B2001	PVLA	b	
	b			LS _A	bar	LS _B	bar				b	
5 l/min PVEH	a	157B3171	PVM	4	157B6210	PVB	157B7005	PVBS	16	157B4033	PVEH	a
	b	157B2001	PVLA						157B2001	PVLA	b	
	b			LS _A	bar	LS _B	bar				b	
	a			5	157B2014	End plate			16		a	
	b										b	
	b			LS _A	bar	LS _B	bar				b	
	a			6	157B80004	PVAS			16		a	
	b										b	
	b										b	

U [Tablica 5] vidimo kratice koje označavaju svaki dio razvodnika. U nastavku su objašnjenja svake kratice.

PVBZ – Proporcionalni ventil osnovni modul bez propuštanja

PVEH – Proporcionalni ventil električni pogon s 4-9% histereze

PVM – Proporcionalni ventil ručna kontrola, ručica

PVLA – Ventil za sprječavanje kavitacije

PVP – Proporcionalni ventil strana modula, uvala; rukavac; utikač

PVB – Proporcionalni ventil osnovni model, ventil kriška

PVBS – Proporcionalni ventil osnovni model, klip

PVE - Proporcionalni ventil električni pogon

PVG – Proporcionalni ventil grupa, multi sekcija ventila

Primjer jedne oznake i šifre:

157B2001 PVLA

PVE, electrical actuation

Description	Code No.			Weight kg [lb]
	Hirsch	AMP	Deut.	
PVEO, on-off 12 V	157B4216	157B4901	157B4291	0.6 [1.3]
24 V	157B4228	157B4902	157B4292	
PVEO-R, on/off 12 V	157B4217	157B4903	-	-
24 V	157B4229	157B4904	-	
PVEM, prop. medium - Standard 12 V	157B4116	-	-	0.9 [2.0]
24 V	157B4128	-	-	1.0 [2.2]
PVEM, prop. medium - Float -> B 12 V	157B4416	-	-	
24 V	157B4428	-	-	
PVEA, active fault mon.	-	157B4734	157B4792	0.9 [2.0]
PVEA, passive fault mon.	-	157B4735	-	
PVEA-DI, active fault mon.	-	157B4736	157B4796	
PVEA-DI, passive fault mon.	-	157B4737	-	
PVEH active fault mon.	157B4032	157B4034	157B4092	1.0 [2.2]
PVEH passive fault mon.	157B4033	157B4035	157B4093	
PVEH float -> B, act. fault	157B4332	-	157B4392	
PVEH float -> A, act. fault	-	157B4338	-	
PVEH-DI active fault mon.	-	157B4036	157B4096	
PVEH-DI passive fault mon.	-	157B4037	-	
PVES, active fault mon.	157B4832	157B4834	157B4892	
PVES, passive fault mon.	157B4833	157B4835	-	

PVMD, PVMR, PVMF, PVH covers

Description	Code No.	Material	Anodized	Weight kg [lb]
PVMD Cover for PVB	157B0001	aluminium	no	0.1 [0.2]
	157B0009		yes	
	157B0021	cast iron	N/A	0.9 [2.0]
PVMR (Frict. Detent)	157B0004	aluminium	no	0.3 [0.6]
	157B0012		yes	
	157B0024	cast iron	N/A	
PVMF (Mech. float position)	157B0005	aluminium	no	0.2 [0.4]
Hydraulic actuation PVH 9/16-18 UNF	157B0007	aluminium	no	
	157B0010		yes	
Hydraulic actuation PVH G1/4	157B0014	cast iron	N/A	
	157B0008		aluminium	no
	157B0011	yes		
	157B0016	cast iron	N/A	0.9 [2.0]

PVLA, anti-cavitation valve

Description	Code No.	Weight	
		kg	[lb]
Plug A or B	157B2002	0.04	0.09
Valve A or B	157B2001	0.05	0.1

Slika 17. Primjer oznake kod razvodnika

3.3.2. Joystickprof-1

Razvodnikom je moguće upravljati polugama na samom razvodniku, ali to nije praktično zbog opasnosti za rukovatelja zbog moguće kolizije s rukom manipulatora. Da bi se izbjegla ta opasnost i poboljšala mogućnost obavljanja zadanih radnji s rukom manipulatora na razvodnik se priključuje daljinski upravljač. Za tu svrhu odabran je proizvod tvrtke Sauer Danfoss JoystickProf-1.



Slika 18. Ručica JoystickProf-1

Pomoću joysticka je moguće istodobno upravljati s tri osi pomoću dva integrirana proporcionalna prekidača u X i Y smjeru i kotačića za treću os. Dostupni su i prekidači za dodatne funkcije.

Prilog 9: Joystick PROF-1

3.3.2.1. Stalak za joystick

Da bi upravljanje s joystickom bilo što jednostavnije i bez ikakvih smetnji izrađen je stalak [Slika 19] na kojem je smješten joystick.



Slika 19. Stalak za joystick

3.4. Komponente mjernog sustava

Mjere se pomaci na svakoj od upravljanih osi. Budući da imamo 2 rotacijske i 1 translacijsku os, tome su prilagođeni i mjerni uređaji.

3.4.1. Translacijska os

Za mjerenje položaja translacijske osi odabran je potezni senzor s potenciometarskim izlazom Micro-epsilon WPS-2100-MK77-P25 [Slika 20]. Sam senzor montiran je na statični dio ruke, a kraj mjerne žice na vrh dvoradnog teleskopskog cilindra.



Slika 20. Potezni senzor s potenciometarskim izlazom

Karakteristike:

- mjerno područje: 0-2100 mm
- rezolucija: 0,55 mm
- senzorski element: žičani potenciometar
- izlazni napon: 0-10 V DC
- izlazna struja: 4-20 mA

Prilog 10: Senzor linernog pomaka MK77

3.4.2. Rotacijske osi

Za mjerenje kuta zakreta na 1. rotacijskoj osi odabran je rotacijski davač kuta zakreta RLS **RM36 VA**, [Slika 21], mjernog područja 360°.

Za mjerenje kuta zakreta na 2. rotacijskoj osi odabran je rotacijski davač kuta zakreta RLS **RM36 VB**, mjernog područja 180°, budući da 2. os ima manji radni kut.



Slika 21. Rotacijski davač kuta zakreta

Karakteristike:

- visokobrzinski magnetni rotacijski davač kuta zakreta
- beskontaktna konstrukcija
- radni napon: 24V
- izlazni napon: 0-10 V DC
- maksimalna brzina: 30 000 okr/min

Prilog 11: Rotacijski senzor RM36

3.4.3. Mjerenje tlaka u tlačnim vodovima

Tlačnim sensorima Siemens SITRANS P220 (7MF1567) [Slika 22], tlak se mjeri na A i B priključku hidromotora te na A i B priključku teleskopskog cilindra kako bismo imali podatak o opterećenju hidromotora i tlakovima u cilindru.



Slika 22. Senzor tlaka

Karakteristike:

- mjerni princip: piezorezistivni mjerač
- mjerenje relativnog tlaka
- mjerno područje: 0-250 bar
- izlazni signal: analogni, napon 0-10 V DC

Prilog 12: Senzor tlaka SITRANS P220 (7MF1567)

3.4.4. Senzor sile podiznog cilindra

Da bismo imali uvid sila u manipulatoru, ispod podiznog cilindra postavljen je tlačno-vlačni senzor aksijalne sile u cilindru. Iz proizvodnog programa tvrtke HBM odabran je model **1-U9C/20kN** [Slika 23] i pripadajuće pojačalo 1-RM4220.



Slika 23. Tlačno – vlačni senzor sile

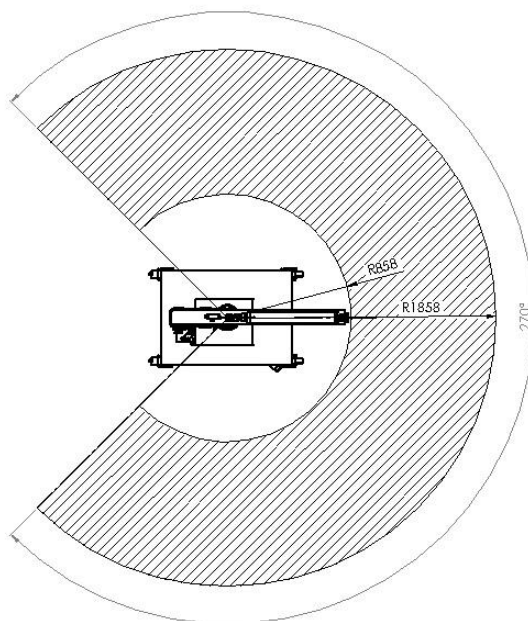
Karakteristike senzora:

- mjerni princip: tlačno-vlačni senzor sile
- mjerni opseg: 2-20 kN

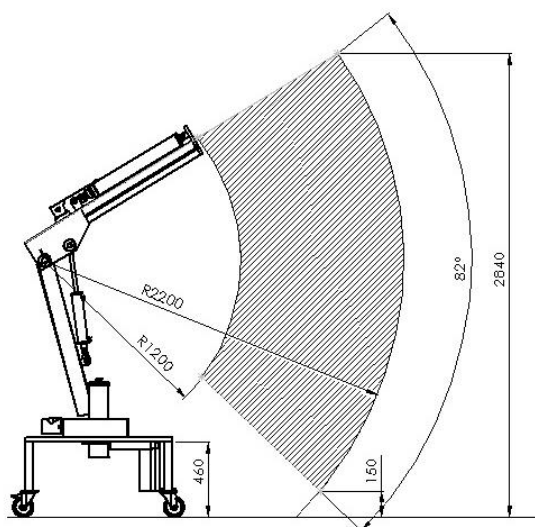
Prilog 13: Senzor sile U9C

4. RADNE KARAKTERISTIKE MANIPULATORA

Manipulatorom je moguće podići predmet s poda i premjestiti ga u neku točku unutar osjenčanog područja prema [Slika 24] i [Slika 25]. To je dio volumena između kugli $\text{Ø}2400$ mm i $\text{Ø}4400$ mm te unutar kuta od 270° .



Slika 24. Kut zakreta manipulatora



Slika 25. Okomiti pomak manipulatora

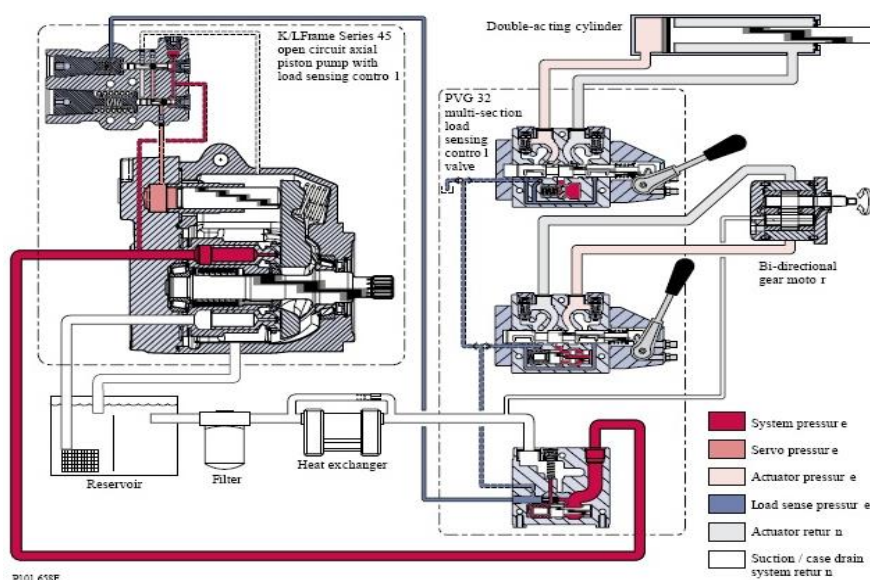
5. REGULACIJA RADA PUMPE IMPULSOM TLAKA

LS regulacija rada pume, odnosno regulacija rada pumpe impulsom tlaka (eng. Load sensing- LS) [13] ima za zadatak prilagođavanje tlaka i protoka pumpe trenutnim zahtjevima izvršnih elemenata. LS sustavi upotrebljavaju se u mobilnoj hidraulici gdje je važno smanjiti gubitke energije. Gibanjem mnogobrojnih radnih elemenata (aktuatora) u mobilnoj hidraulici (kontrola dizalice i robota, kontrola vozila) obično se ostvaruje regulacijom protoka pumpe u hidrauličkom sustavu.

Kao što je navedeno, glavni zadatak LS-a temelji se na prilagođavanju tlaka i protoka pumpe zahtjevima potrošača, odnosno trenutnim uvjetima rada. Kao rezultat dobije se sustav malih gubitaka energije. LS sustav omogućava vrlo precizno upravljanje traženih hidrauličkih funkcija koje bi bilo vrlo teško postići na bilo koji drugi način bez značajne pretvorbe velike količine energije u neželjenu toplinu i vrlo štetno zagrijavanje hidrauličkog ulja.

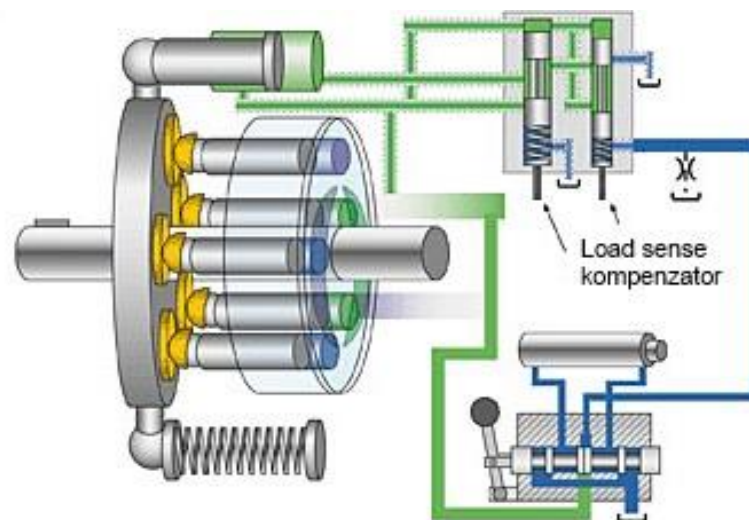
5.1. Načelo rada LS sustava

Kod sustava koji nemaju jednostavnu i ponovljivu radnu sekvencu značajne su varijacije tlaka i protoka. Karakterističan primjer različitih brzina aktuatora i promjenjivih opterećenja je mobilna hidraulika. Dodatno, u mobilnoj hidraulici svako pregrijavanje ulja štetno utječe na sustav i značajno utječe na potrošnju goriva. Shema LS sustava [Slika 26] prikazuje spoj pumpe i hidrauličkog razvodnika s kojeg ide povratna veza na pumpu.



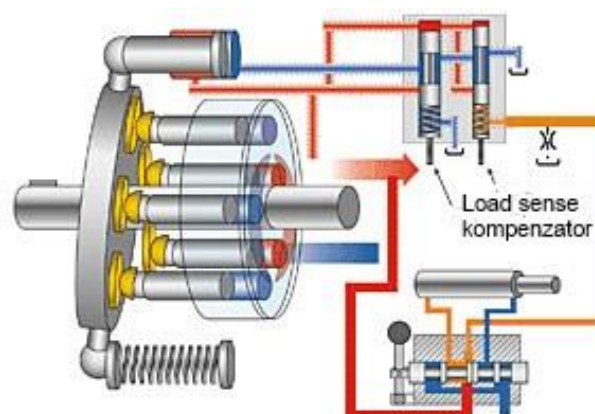
Slika 26. Shema rada LS sustava [14]

Osnovni smisao ove kombinacije je mogućnost uštede energije jer LS sustav ne dopušta pumpi rad na maksimalnom tlaku, nego upravo onom koji je dovoljan za pokretanje izvršnih elemenata. Sustav je vrlo precizan za upravljanje hidrauličkim funkcijama. Kada u sustavu nije potreban tlak za izvršavanje neke funkcije, nagibna ploča u pumpi je u takvom položaju da pumpa daje samo tlak potreban za održavanje sustava [Slika 27].



Slika 27. Neopterećeni LS sustav [15]

Kada izvršni element treba tlak i protok, pumpa dobiva ulazni signal s razvodnika te se nagibna ploča zakreće i pumpa daje potreban tlak u sustav [Slika 28].



Slika 28. Opterećeni LS sustav [15]

Osnovne značajke LS regulacije rada pumpe:

- jednostavno rasterećenje pumpe i rad pumpe na niskom tlaku,
- konstantan protok kroz razvodnik bez obzira na promjenu brzine vrtnje pogonskog stroja,
- konstantan protok kroz razvodnik bez obzira na iznos opterećenja izvršnog elementa,
- manje zagrijavanje ulja,
- manji gubici energije.

Nedostaci LS sustava:

- složenost sustava,
- održavanje sustava,
- potreba za uvježbanim i sposobnim rukovateljima,
- cijena.

6. RUČNI I AUTOMATSKI NAČIN UPRAVLJANA

6.1. Ručni način upravljanja manipulatorom

Upravljanje elektrohidrauličkim manipulatorom (EHROM) moguće je na tri načina. Jedan od načina je korištenje mehaničkih poluga koje su smještene direktno na samom razvodniku. Pomicanjem jedne od poluga gore ili dolje upravljamo izvršnim elementom. Svaka poluga se koristi za neki određeni izvršni element. Takva izvedba upravljanja je najjednostavnija, nema nikakvih žica ili bilo kakvog programiranja manipulatora. Nedostatak ovog upravljanja je taj da se poluge nalaze na razvodniku, a razvodnik se nalazi pokraj ruke manipulatora pa dolazi do opasnosti za rukovatelja zbog moguće kolizije s rukom manipulatora.

Drugi način upravljanja elektrohidrauličkim manipulatorom (EHROM) izveden je preko joystick-a tvrtke Sauer Danfoss Joystick Prof-1 kako je opisano u poglavlju 3.3.2. Upravljač je ergonomski oblikovan za učestalu upotrebu u radnim strojevima i ostaloj profesionalnoj opremi. Prednost ovakvog načina upravljanja je što upravljač držimo jednom rukom i pomicanjem u jednu od strana ili pritiskom na određeni prekidač upravljamo izvršnim elementom. Moguće je istodobno upravljati s tri osi. Upravljač je udaljen nekoliko metara od manipulatora te tako imamo bolji pregled radnog prostora manipulatora i rukovatelj nije u opasnosti zbog moguće kolizije s rukom manipulatora.

6.2. Automatski način upravljanja manipulatorom

Treći način upravljanja je automatski način preko računala. Elektrohidraulički manipulator ima mogućnost spajanja na računalo. U ovom slučaju na računalu izradimo neku simulaciju ili napišemo neki od programa i preko računala upravljamo izvršnim elementima manipulatora.

7. IZRADA DIJELOVA I MONTAŽA EHROM-A

Nosač, spremnik ulja i ostali dijelovi za pogonski dio elektrohidrauličkog robotskog manipulatora izrađeni su u tvrtci Rasco d.o.o u Kalinovcu. Nakon izrade potrebnih dijelova slijedi montaža pogonskog agregata. Kroz par slika je prikazana montaža pogonskog agregata.



Slika 29. Dijelovi za pogonski agregat



Slika 30. Nosač pogonskog agregata



Slika 31. Elektromotor i LS pumpa

Nakon što je LS pumpa spojena s elektromotorm, sve zajedno postavljeno je na nosač predviđen za pogonski agregat [Slika 32].



Slika 32. Pogonski agregat

Nakon što je pogonski agregat uspješno smješten na nosač, postavlja se gornja ploča na kojoj se nalazi razvodnik i ruka manipulatora [Slika 33].



Slika 33. Ploča i pogonski agregat

Sada je potrebno postaviti elektroormar i pripadajuće sklopke te spojiti sve potrebne žice, [Slika 34].

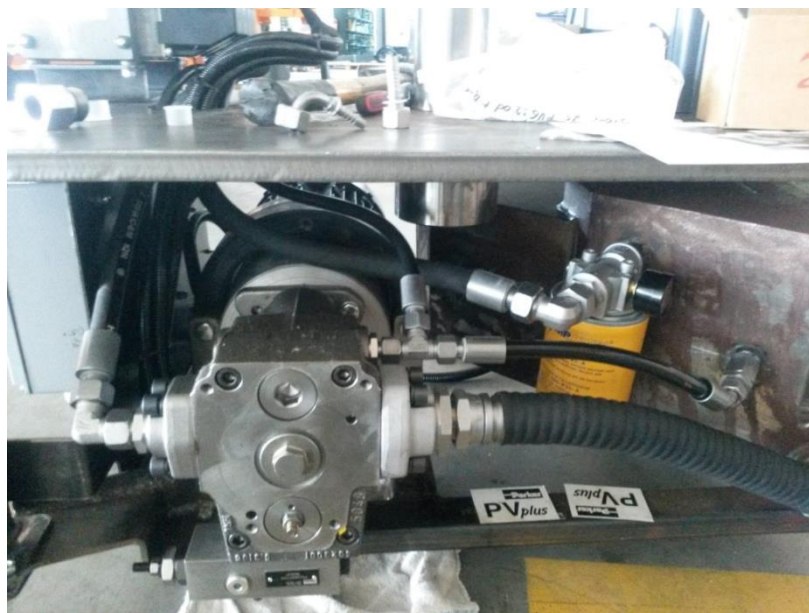


Slika 34. Elektroormar sa pripadajućim sklopkama



Slika 35. Spajanje električnog pogona razvodnika

Sljedeći korak je spajanje pogonskog agregata i razvodnika prema hidrauličkoj shemi [Slika 36].



Slika 36. Spajanje hidraulike



Slika 37. Spajanje razvodnika sa pumpom



Slika 38. EHROM

8. ZAKLJUČAK

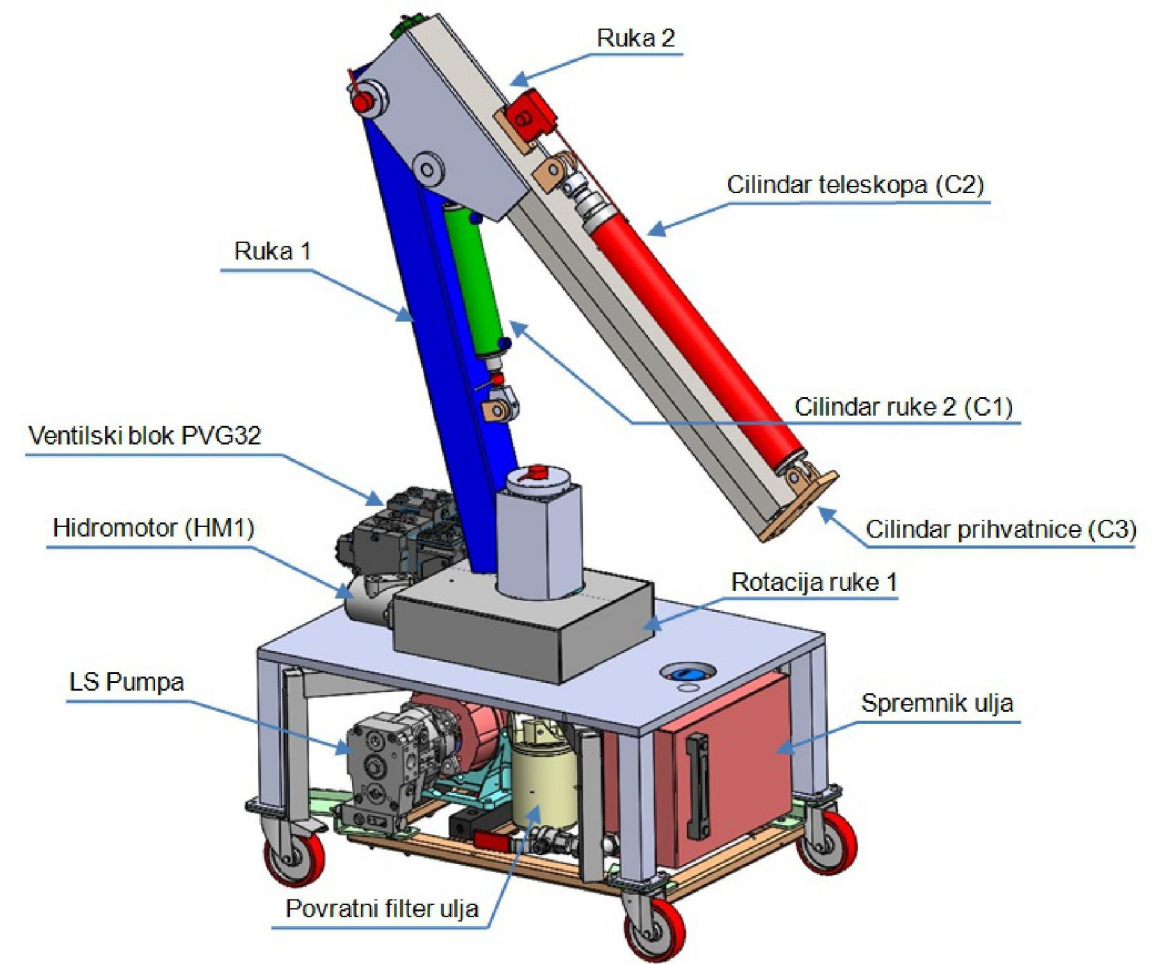
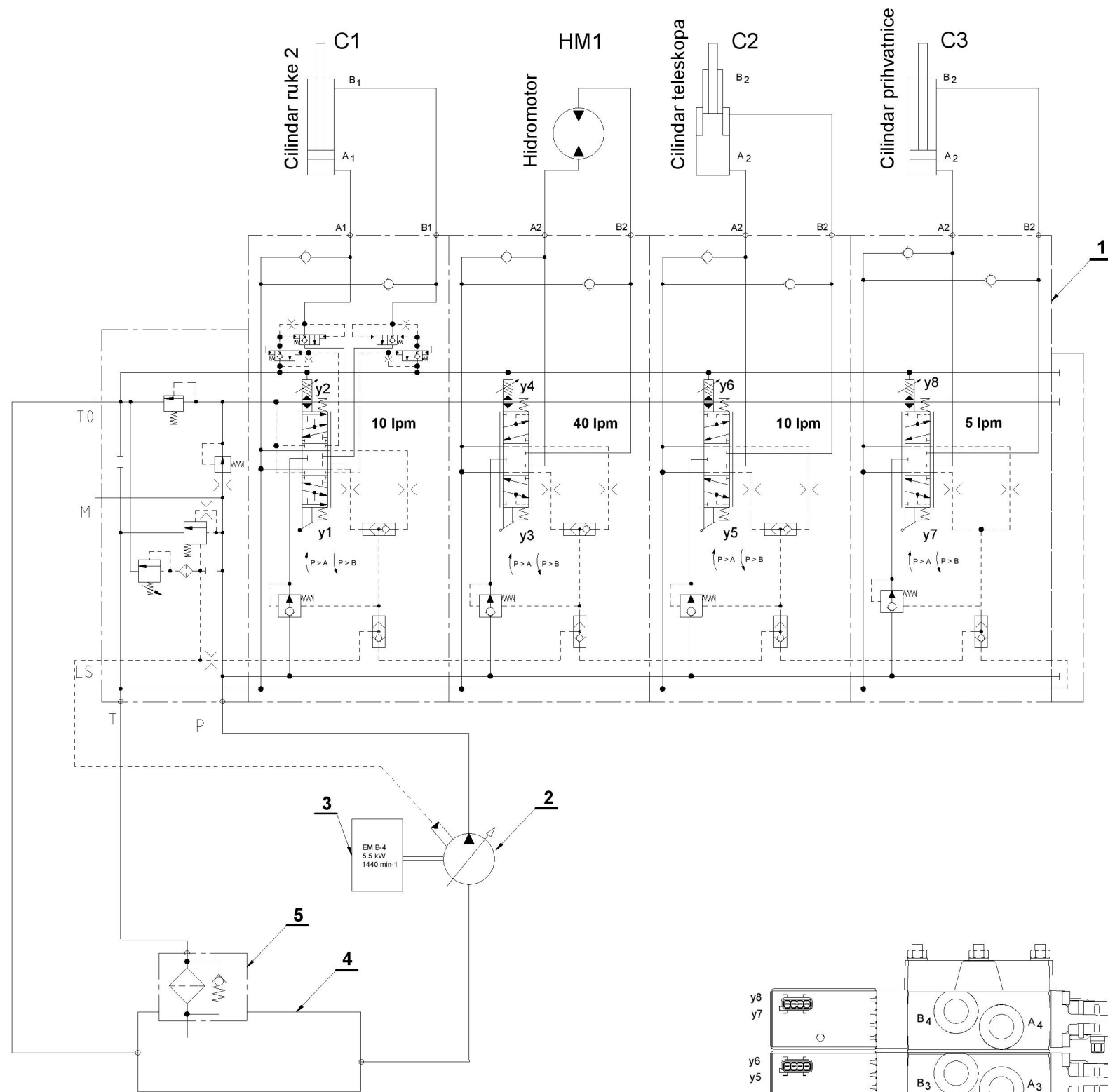
U radu je obrađen izbor električnih i hidrauličkih komponenti te mjernih senzora za izradu elektrohidrauličkog robotskog manipulatora. Kao glavna pogonska komponenta korištena je LS pumpa. Opisana su područja LS sustava i navedene prednosti i nedostaci LS sustava. LS sustav omogućuje konstantan protok prema izvršnom elementu, a time i konstantnu brzinu izvršnog elementa bez obzira na promjene u iznosu opterećenja izvršnog elementa ili promjene brzine vrtnje pogonskog stroja hidrauličke pumpe. LS sustav ne „dopušta” rad pumpe na maksimalnom tlaku i na taj način štiti pumpu, dok manji gubici snage uzrokuju manje zagrijavanje ulja u odnosu na „obične” hidrauličke sustave. Stoga najveću primjenu LS sustav nalazi u mobilnoj hidraulici gdje je važno smanjiti zagrijavanje hidrauličkog ulja, odnosno smanjiti gubitke viskoznosti i potrošnju goriva. Montažom dijelova i glavnih komponenti dobivena je izvedba manipulatora koja će se koristiti u obrazovne svrhe. Studenti će imati mogućnost izrade radova iz područja automatizacije te tako nadograđivati sustav manipulatora.

LITERATURA

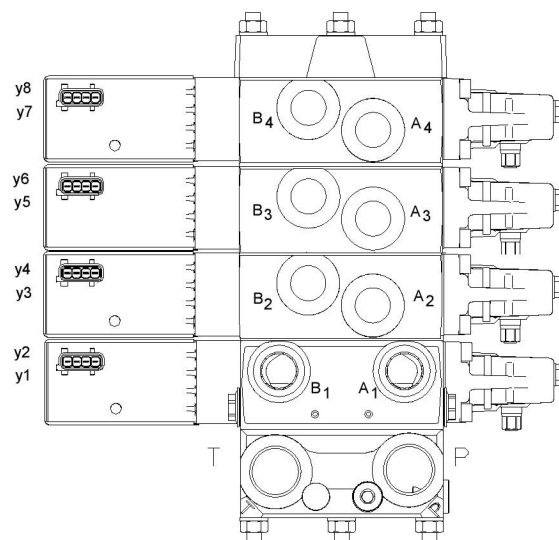
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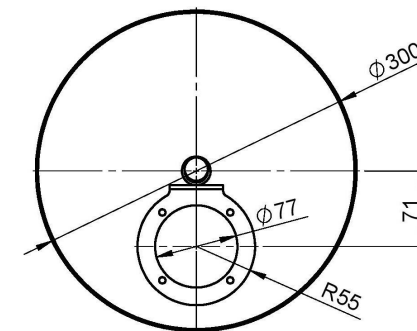
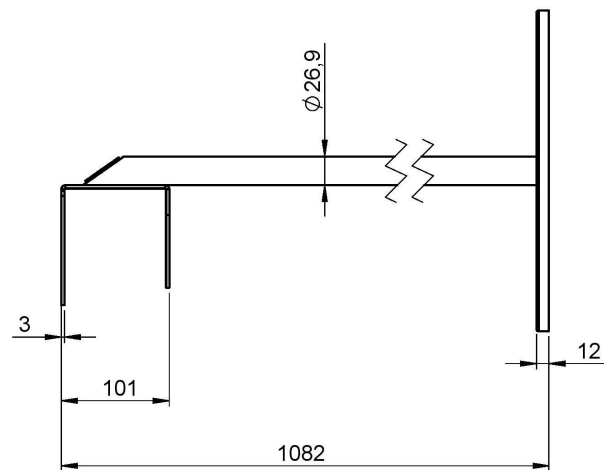
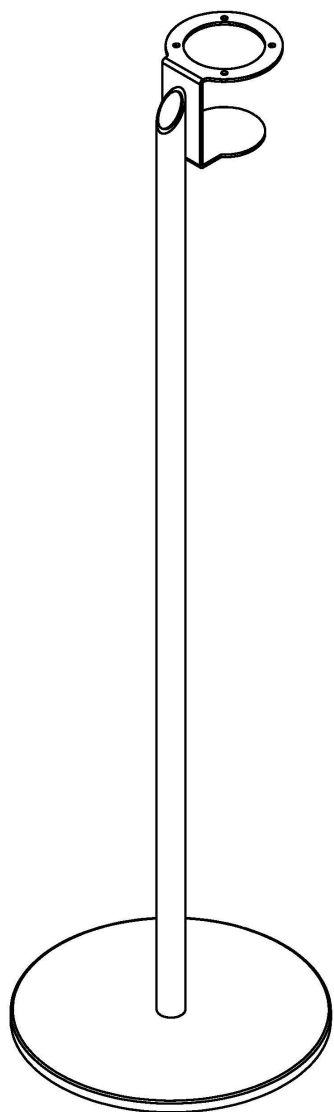


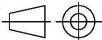

5	Povratni filter ulja		1
4	Spremnik ulja		1
3	Elektromotor B-4		1
2	LS pumpa		1
1	Ventilski blok PVG32		1
Poz	Naziv	Kat.broj	Kom



Stanje	Zavojnica	y1	y2	y3	y4	y5	y6	y7	y8
Dizanje ruke 2		X							
Spuštanje ruke 2			X						
Rotacija ruke 1 (lijevo)				X					
Rotacija ruke 1 (desno)					X				
Izvlačenje teleskopa						X			
Uvlačenje teleskopa							X		
Prihvatnica otvaranje								X	
Prihvatnica zatvaranje									X

Kom	Naziv		Kat. broj	
Konstruirao:	08.05.2015.	IVAN JANKOVIC		Potpis
Odobrio:	IVICA IVANIC			
Mjerilo:	Naziv:		Broj proizvoda:	
HIDRAULIČNA SHEMA EHROM			Broj sklopa:	
			Broj pozicije:	
ZAMJENA ZA:	ZAMJENJEN SA:	BROJ OBRASCA:		
Izradio:	Kontrolirao:	Odobrio:		



 Mjerilo: M 1:10	Datum:	Ime i prezime:	Potpis:		
	Konstruirao:	-	-		
	Crtao:	-	-		
	Odobrio:	-	-		
ISO - TOL	Naziv:			Broj sklopa:	
	Nosač joysticka			Ugradbene dimenzije:	
				Proizvod:	
Knjiga br.:	Površinska zaštita:	Termička obrada:	Masa:	Komada:	
	-	-	8.58 kg	-	
Crtež br.:	Sve netolerirane mjere raditi na toleranciju H11/h11			List 1 od 1	
				Format A4	

Prilog 1: Linearna vodilica HGH35 HA

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CZ EN SK RU BG

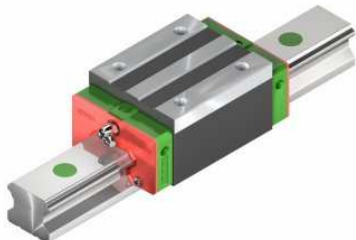
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HGH

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- POSITIONING SYSTEMS
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Square linear guide block

Applications:

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- Heavy cutting machines
- Grinding machines
- Injection molding machine
- Automatic equipment
- High speed transfer device

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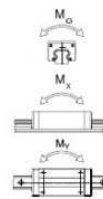
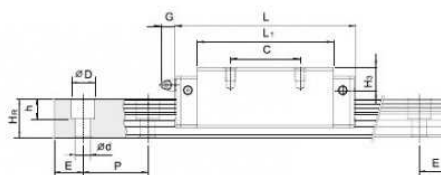
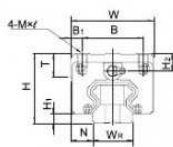
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- Mazání



kolejiště: HGR-R

Part number	H	W	B	C	L	Mx1	C _{dyn} [N]	C _{stat} [N]	M _o [Nm]	M _x [Nm]	M _y [Nm]	3D (STP)
HGH15CA	28	34	26	26	61,4	M4x5	11380	25310	170	150	150	
HGH20CA	30	44	32	36	77,5	M5x6	17750	37840	380	270	270	
HGH20HA	30	44	32	50	90,3	M5x6	21180	48840	480	470	470	
HGH25CA	40	48	35	35	83	M6x8	26480	56190	640	510	510	
HGH25HA	40	48	35	50	103,6	M6x8	32750	76000	870	880	880	
HGH30CA	45	60	40	40	97,4	M8x10	38740	83060	1060	850	850	
HGH30HA	45	60	40	60	120,4	M8x10	47270	110130	1400	1470	1470	
HGH35CA	55	70	50	50	112,4	M8x12	49520	102870	1730	1200	1200	
HGH35HA	55	70	50	72	138,2	M8x12	60210	136310	2290	2080	2080	
HGH45CA	70	86	60	60	138	M10x17	77570	155930	3010	2350	2350	
HGH45HA	70	86	60	80	169,8	M10x17	94540	207120	4000	4070	4070	
HGH55CA	80	100	75	75	165,7	M12x18	114440	227810	5660	4060	4060	
HGH55HA	80	100	75	95	203,8	M12x18	139350	301260	7490	7010	7010	
HGH65CA	90	126	76	70	198,2	M16x20	163630	324710	10020	6440	6440	
HGH65HA	90	126	76	120	257,6	M16x20	208360	457150	14150	11120	11120	

Prilog 2: Končar elektromotori

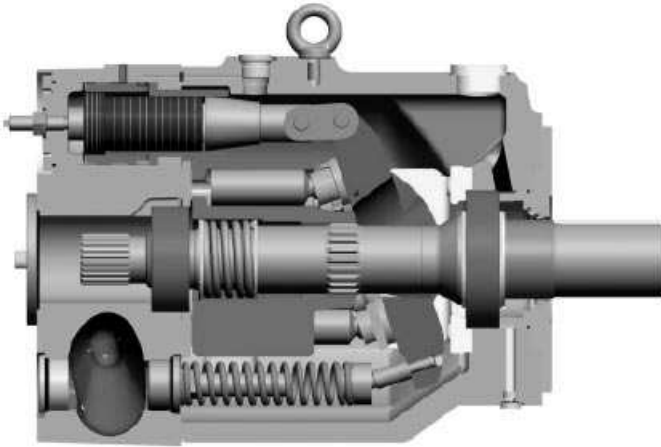
Tablica 2.3. / Table 2.3. / Tabelle 2.3.

2p=4			1500 min ⁻¹			400V / 50Hz						1800 min ⁻¹ / 440V / 60Hz		
P (kW)	Motor type	n (min ⁻¹)	η (%)	cos φ	I _n (A)	$\frac{I_k}{I_n}$	M _n (Nm)	$\frac{M_k}{M_n}$	$\frac{M_{max}}{M_n}$	J (kgm ²)	m (kg)	P (kW)	n (min ⁻¹)	I _n (A)
0.06	5AZ 56A-4	1415	58	0.62	0.25	2.8	0.4	2.1	2.1	0,0001791	3.3	0.06	1700	0.25
0.09	5AZ 56B-4	1400	58	0.60	0.38	2.6	0.6	1.9	1.9	0,0001791	3.2	0.09	1680	0.35
0.12	5AZH 56B-4	1350	58	0.70	0.41	3.0	0.85	1.9	1.9	0,0001791	3.3	0.12	1620	0.41
0.12	5AZ 63A-4	1360	58	0.75	0.44	3.0	0.85	2.0	2.1	0,0002211	3.5	0.12	1630	0.44
0.18	5AZ 63B-4	1370	60	0.72	0.60	3.3	1.3	2.2	2.4	0,0002948	4.2	0.2	1640	0.60
0.25	5AZH 63B-4	1310	60	0.78	0.80	2.7	1.8	1.8	1.8	0,0002948	4.2	0.3	1570	0.80
0.25	5AZ 71A-4	1370	61	0.72	0.85	3.4	1.8	2.0	2.1	0,0004533	4.9	0.3	1640	0.85
0.37	5AZ 71B-4	1360	66	0.75	1.1	3.4	2.5	2.0	2.1	0,0006421	5.7	0.4	1630	1.1
0.55	5AZH 71C-4	1380	70	0.70	1.7	3.6	3.8	2.2	2.3	0,0007932	8.0	0.6	1630	1.7
0.55	5AZ 80A-4	1390	70	0.76	1.6	4.1	3.8	2.0	2.1	0,0010111	7.9	0.6	1670	1.6
0.75	5AZ 80B-4	1390	75	0.76	1.9	4.1	5	2.2	2.3	0,0013000	9.2	0.8	1670	1.9
1.1	5AZH 80C-4	1360	73	0.76	3.0	4.0	7.5	2.4	2.3	0,0015889	11	1.2	1630	3.0
1.1	5AZ 90S-4	1380	75.5	0.78	2.7	4.2	7.5	2.2	2.3	0,0236600	11.3	1.2	1660	2.7
1.5	5AZ 90L-4	1380	78	0.80	3.5	4.4	10.5	2.2	2.3	0,0031550	13.8	1.7	1660	3.5
2.2	5AZH 90LC-4	1410	75	0.78	5.4	4.4	15	2.5	2.6	0,0036475	15.3	2.5	1630	5.4
2.2	5AZ 100LA-4	1410	81	0.80	4.9	5.0	15	2.2	2.3	0,0055715	19.4	2.5	1690	4.9
3	5AZ 100LB-4	1410	82.5	0.82	6.5	5.7	20	2.5	2.8	0,0070838	24	3.4	1690	6.5
3.5	5AZH 100LB-4	1410	82	0.77	8.0	5.8	25	2.7	2.9	0,0070838	25	4.0	1690	8
4	5AZ 112M-4	1435	84.5	0.80	8.5	7	27	2.8	3.1	0,0121970	33	4.5	1720	8.5
5.5	5AZH 112M-4	1410	82	0.78	12.5	5.5	35	2.7	3.0	0,0121970	33	6.2	1690	12.5
5.5	5AZ 132S-4	1435	85.5	0.85	11	5.9	35	2.5	3.0	0,0201923	39	6.2	1720	11
7.5	5AZ 132M-4	1440	87	0.83	15	6.5	50	2.7	3.2	0,0276316	49	8.5	1730	15
9.5	5AZ 132MA-4	1440	88	0.82	19	6.7	65	2.9	3.4	0,0349191	56	11	1730	19
11	5AZH 132MA-4	1430	88	0.82	22	6.6	75	2.7	2.9	0,0349191	62	12.5	1720	22.0
11	5AZ 160M-4	1460	88.6	0.82	22	7.3	75	2.8	3.3	0,0612475	80	12.5	1750	22.0
15	5AZ 160L-4	1460	89.7	0.83	29	7.0	100	2.8	3.1	0,0822467	95	17	1750	29.0
18.5	7AZ 180M-4	1460	90.5	0.83	35.5	7.5	120	2.7	3.1	0,1261614	183	21	1750	35.5
22	7AZ 180L-4	1460	91	0.84	41.5	7.5	145	2.8	3.1	0,1514499	199	25	1750	41.5
30	7AZ 180LA-4	1460	91	0.84	57	7.5	195	2.8	3.1	0,1891016	225	34	1750	57
30	7AZ 200L-4	1470	93.5	0.85	54.5	7.5	195	2.4	2.6	0,2431014	268	34	1760	54.5
37	7AZ 225S-4	1475	93.5	0.85	67	7.1	240	2.3	2.6	0,3823324	322	42	1780	67
45	7AZ 225M-4	1470	94.3	0.85	81	7.2	290	2.4	2.6	0,4622828	354	52	1780	81
55	7AZ 250M-4	1480	94.2	0.86	98	7.5	355	2.4	2.8	0,7180200	475	63	1780	98
75	7AZ 280S-4	1480	93.5	0.83	140	7.5	485	2.4	2.8	1,1863770	620	85	1780	140
90	7AZ 280M-4	1480	94.5	0.83	165	7.5	580	2.4	2.8	1,4242154	680	103	1780	165
110	7AZ 315S-4	1485	94.5	0.84	200	7.4	705	1.6	2.5	2,5126648	930	124	1785	200
132	7AZ 315M-4	1485	94.5	0.84	240	7.0	850	1.6	2.5	3,0983389	1050	149	1785	240
160	7AZ 315LA-4	1485	95.0	0.82	295	7.0	1030	1.6	2.5	3,9358939	1080	180	1785	295
200	7AZ 315LB-4	1490	95.1	0.82	370	6.0	1280	1.5	2.3	4,6065522	1180	225	1790	370

Prilog 3: Parker pumpa

With thru drive for single and multiple pumps

Swash plate type for open circuit



Technical Features

- Low noise level
- Fast response
- Service-friendly
- High self-priming speed
- Compact design
- Thru drive for 100% nominal torque

Technical Data

		PV016	PV020	PV023	PV028	PV032	PV040	PV046	PV140	PV180	PV360
Frame size		1	1	1	1	2	2	2	4	4	5
Max. Displacement	[cm ³ /rev.]	16	20	23	28	32	40	46	140	180	360
Output flow at 1500 rpm	[l/min]	24	30	34,5	42	48	60	69	270	405	540
Nominal pressure pN	[bar]	350	350	350	350	350	350	350	350	350	350
Max. pressure pmax at 20% working cycle	[bar]	420	420	420	420	420	420	420	420	420	420
Case drain pressure, continuous	[bar]	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5
Case drain pressure, max. peak	[bar]										2,0
Min. Inlet pressure, abs.	[bar]	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8
Max. Inlet pressure	[bar]	16	16	16	16	16	16	16	16	16	16
Input power at 1500 rpm and 350 bar	[kW]	15,5	19,5	22,5	27,5	31	39	45	136	175	350
Max speed at 1 bar inlet pressure	[rpm]	3000	3000	3000	3000	2800	2800	2800	2400	2200	1750
Moment of inertia	[kgm ²]	0,0017	0,0017	0,0017	0,0017	0,0043	0,0043	0,0043	0,030	0,030	0,103
Weight	[kg]	19	19	19	19	30	30	30	90	90	180

General Information

Fluid recommendations

Premium quality hydraulic mineral fluid is recommended, like HLP oils to DIN 51524, part 2. Brugger- value has to be 30 N/mm² minimum for general application and 50 N/mm² for heavily loaded hydraulic equipment and fast cycling machines and/or high dynamic loads, measured in accordance with DIN 51 347-2. See also Document HY30-3248/UK Parker Hydraulic Fluids.

Viscosity

The normal operating viscosity should range between 16 and 100 mm²/s (cSt). Max. start-up viscosity is 800 mm²/s (cSt).

Filtration

For maximum pump and system component functionality and life, the system should be protected from contamination by effective filtration.

Fluid cleanliness should be in accordance with ISO classification ISO 4406:1999. The quality of filter elements should be in accordance with ISO standards. General hydraulic systems for satisfactory operation: Class 20/18/15, according to ISO 4406:1999. Recommended cleanliness for maximum component life and functionality: Class 18/16/13, according to ISO 4406:1999

Seals

Check hydraulic fluid specification for chemical resistance of seal material.

Check temperature range of seal material and compare with max. system and ambient temperature.

N - Nitrile -40 ... +90 °C

Note: The highest fluid temperature will be at the drain port of the pump, up to 25 °C higher than in the reservoir.



axial piston pump variable displacement

size and displacement

rotation

variation

mounting interface

threads code

thru drive code

coupling code

seals

control

see next page →

Code	Displacement	Size
032	32 cm ³ /rev	2
040	40 cm ³ /rev	2
046	46 cm ³ /rev	2

Code	Seals
N	NBR
V	FPM
W	NBR with PTFE shaft seal
P	FPM with PTFE shaft seal

Code	Rotation ¹⁾
R	Clockwise
L	Counter clockwise

¹⁾ When looked on shaft

Code	Variation
1	Standard
9	Special adjustment ²⁾

²⁾ requires Kxxxx number

Code	Mounting interface	Shaft
K	metr. ISO 4-hole flange Ø250 mm	Cylindric, key
L	3019/2 4-hole flange Ø250 mm	Splined, DIN 5480
D	SAE 4-hole flange SAE E	Cylindric, key
E	ISO 4-hole flange SAE E	Splined, DIN 5480
	3019/1	

Code	Port ³⁾	Threads ⁴⁾
1	BSPP	metric
3	UNF	UNC
7	ISO 6149	UNC
8 ⁵⁾	ISO 6149	metric

Code	Coupling for thru drive	as single part ⁶⁾
1	Single pump, no coupling	
H	with coupling 25 x 1.5 x 15, DIN 5480	MK-PVBGxK01
J	with coupling 32 x 1.5 x 20, DIN 5480	MK-PVBGxK02
Y	with coupling SAE A 9T-16/32 DP	MK-PVBGxK11
A	with coupling SAE - 11T-16/32 DP	MK-PVBGxK12
B	with coupling SAE B 13T-16/32 DP	MK-PVBGxK13
C	with coupling SAE B-B 15T-16/32 DP	MK-PVBGxK14
D	with coupling SAE C 14T-12/24 DP	MK-PVBGxK15

Code	Thru drive option	
No adaptor for 2nd pump		
T	Single pump prepared for thru drive	
with adaptor for 2nd pump		
	as single part ⁶⁾	
A	SAE A, Ø 82.55 mm	MK-PVBGxAMN
B	SAE B, Ø 101.6 mm	MK-PVBGxBMN
C	SAE C, Ø 127 mm	MK-PVBGxCMN
G	metric, Ø 63 mm	MK-PVBGxGMN
H	metric, Ø 80 mm	MK-PVBGxHMN
J	metric, Ø 100 mm	MK-PVBGxJMN
K	metric, Ø 125 mm	MK-PVBGxKMN

See dimensions for details

⁶⁾ to be ordered separately as single part
 x= Frame size, see displacement.

³⁾ Drain, gauge and flushing ports

⁴⁾ All mounting and connecting threads

⁵⁾ Mounting interface, code K and L only

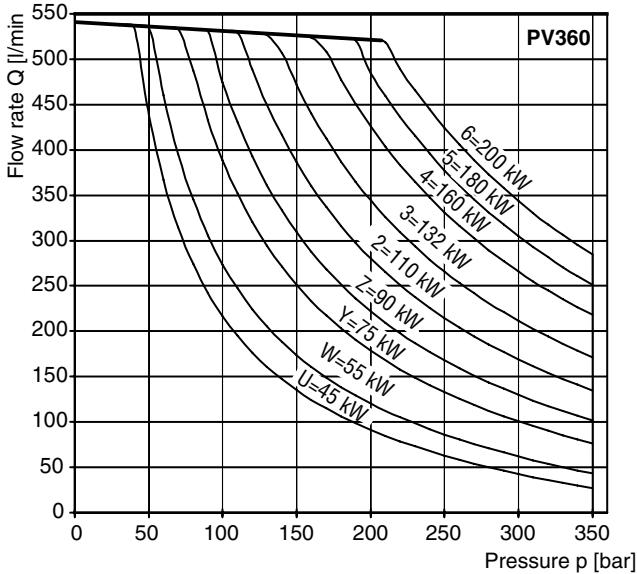
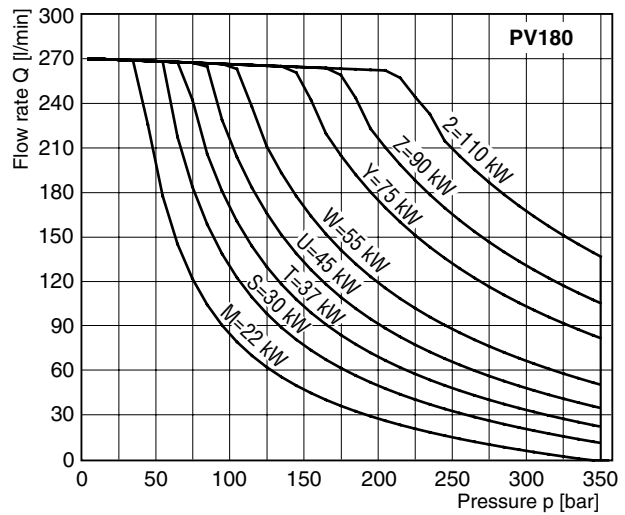
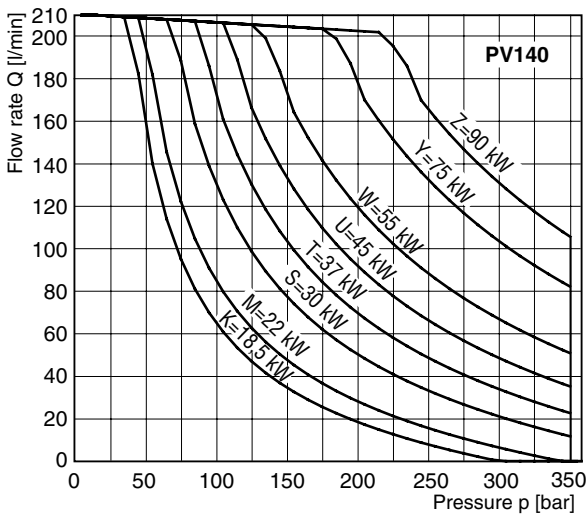
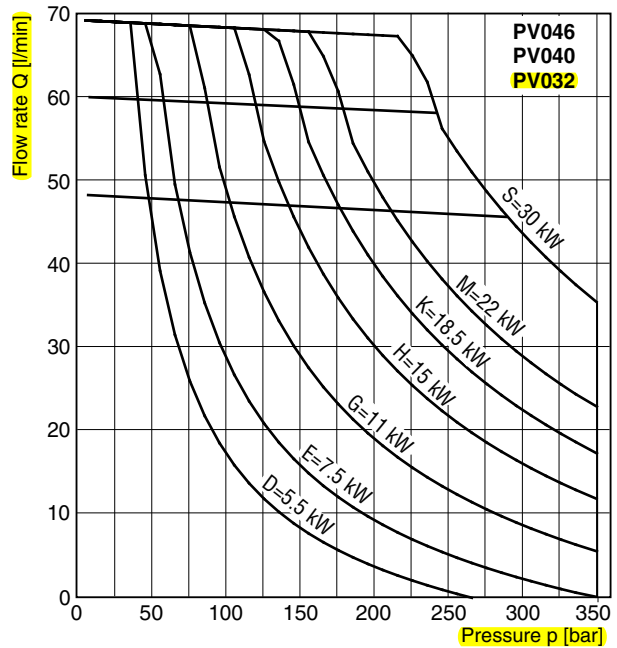
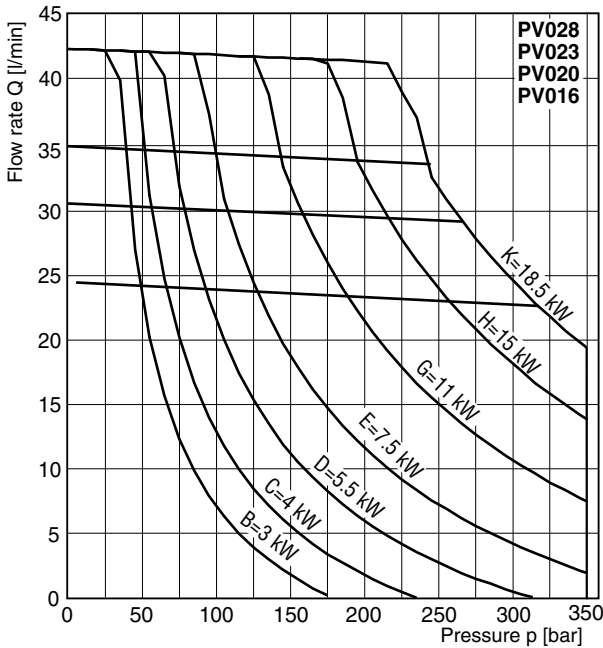
Code			Control options
0	0	1	No control
1	0	0	With cover plate, no control function
M	M		Standard pressure control, integrated pilot valve
M	R		Remote pressure control, integrated pilot valve
M	F		Load Sensing (flow) control, integrated pilot valve
M	T		Two spool LS control
			Control variation
		C	Standard version ¹⁾
		1	NG6 interface top side for pilot valves
		W	With unloading function, 24VDC solenoid ¹⁾
		K	Prop.-pilot valve type PVACRE..35 mounted
		Z	Without integrated pilot valve, NG6 interface, for mounting of accessory code PVAC*
		P	MT1 with mounted pilot valve PVAC1P ²⁾

1) not for MT
 2) only for MT

Horse power / Torque control									
Displacem.				Code		Nominal HP at 1.500 rpm	Nominal torque		
032									
046									
					D	5.5 kW	35 Nm		
					E	7.5 kW	50 Nm		
					G	11 kW	71 Nm		
					H	15 kW	97 Nm		
					K	18.5 kW	120 Nm		
					M	22 kW	142 Nm		
					S	30 kW	195 Nm		
Function									
					L	Horse power control with pressure control			
					C	Horse power control with load sensing (single spool)			
Control variation									
					C	Standard version			
					1	NG 6 interface top side			
					W	With unloading function, 24 VDC solenoid			
					K	Prop.-pilot valve type PVACRE..35 mounted			
					Z	Without integrated pilot valve, NG6 interface, for mounting of accessory code PVAC*			

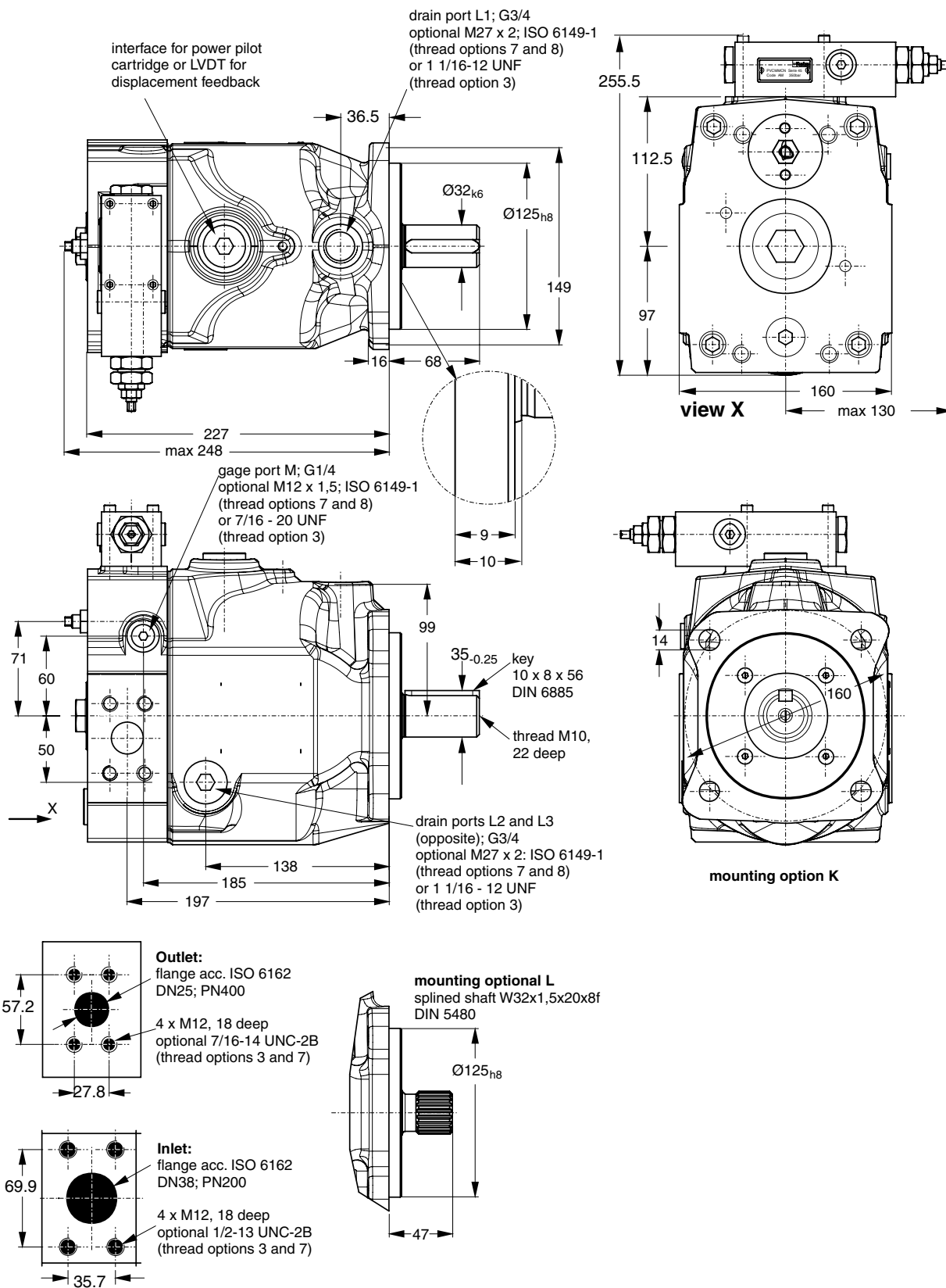
Code			Control option
			electro hydraulic control
F	P	V	Proportional displacement control, no pressure compensation
U	P		Proportional displacement control, with pressure compensation
			Control variation
		R	pilot operated pressure control, open NG6 interface
		K	pilot operated pressure control, proportional pilot valve type PVACRE..35 mounted
		M	pilot operated pressure control, pressure sensor and proportional pilot valve type PVACRE..35 mounted for pressure control and/or power control

Typical Horse Power/Torque Control Characteristics



Speed : n = 1500 rev/min
 Temperature : t = 50 °C
 Fluid : HLP, ISO VG46
 Viscosity : $\nu = 46 \text{ mm}^2/\text{s}$ at 40 °C
 Pressure : Maximum 350 bar, depending on frame size and
 HP level

PV032 - 046, metric version



Shown is a clockwise rotating pump with standard pressure compensator.
 Counter clockwise rotating pumps have inlet, outlet and gauge port reversed.

Prilog 4: Povratni filter ulja

Description

Machine

Author

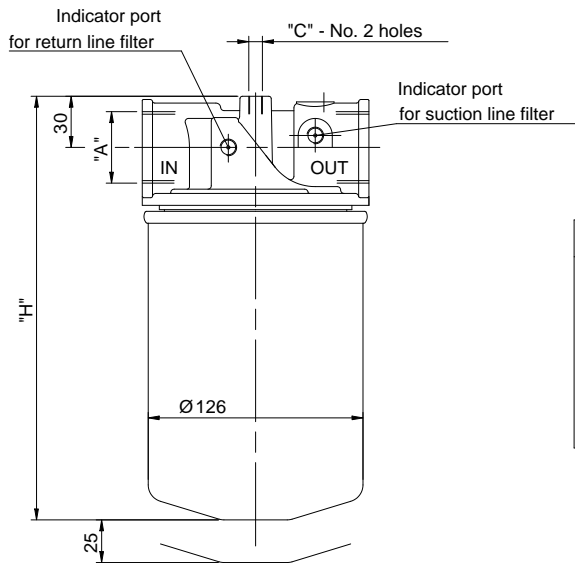
Project

Pressure	0	bar	Fluid	HLP
Flow rate	50	l/min	Fluid type	ISO VG 22 (SUS 103)
D P max	0.15	bar	Viscosity	22 cst
Temperature	40	°C		
Filtration	M25 25 µm nominal square		Max operating pressure	1 bar - 14.5 psi

SPIN-ON FILTER

Filter type	Size	Bypass	Connection	Filtration	Seals
MPS	100	S	G1	M25	A
Indicator					

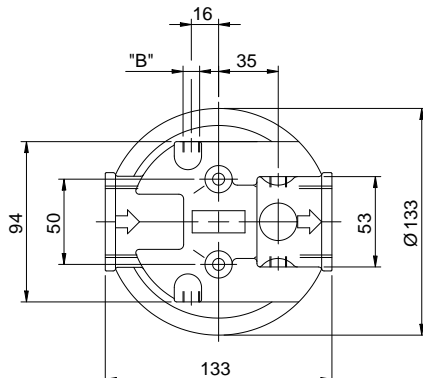
DP Housing	0.04	bar	Element type	8CS100M25A
DP Element	0.02	bar	Connections	1 1/4" BSP
DP complete filter	0.06	bar	No.Elem. in the housing	1



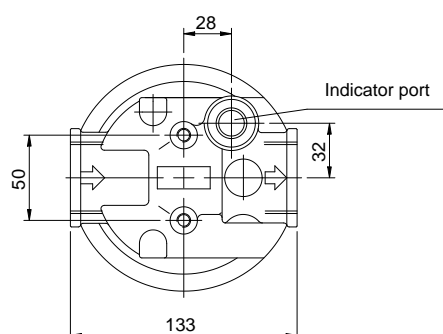
Thread connections			
Type	"A" connection	"B"	"C"
G1	G 1 1/4"	G 1/8"	M 8
G2	1 1/4" NPT	1/8" NPT	5/16" UNC
G3	SAE 20 - 1 5/8" 12 UN	1/8" NPT	5/16" UNC
G4	SAE 16 - 5/16" - 12 UN	1/8" NPT	5/16" UNC
G5	G 1"	G 1/8"	M 8
G6	1" NPT	1/8" NPT	5/16" UNC

Lengths	
Type	"H"
100-101	251
150-151	296

MPS 100-150 Series



MPS 101-151 Series



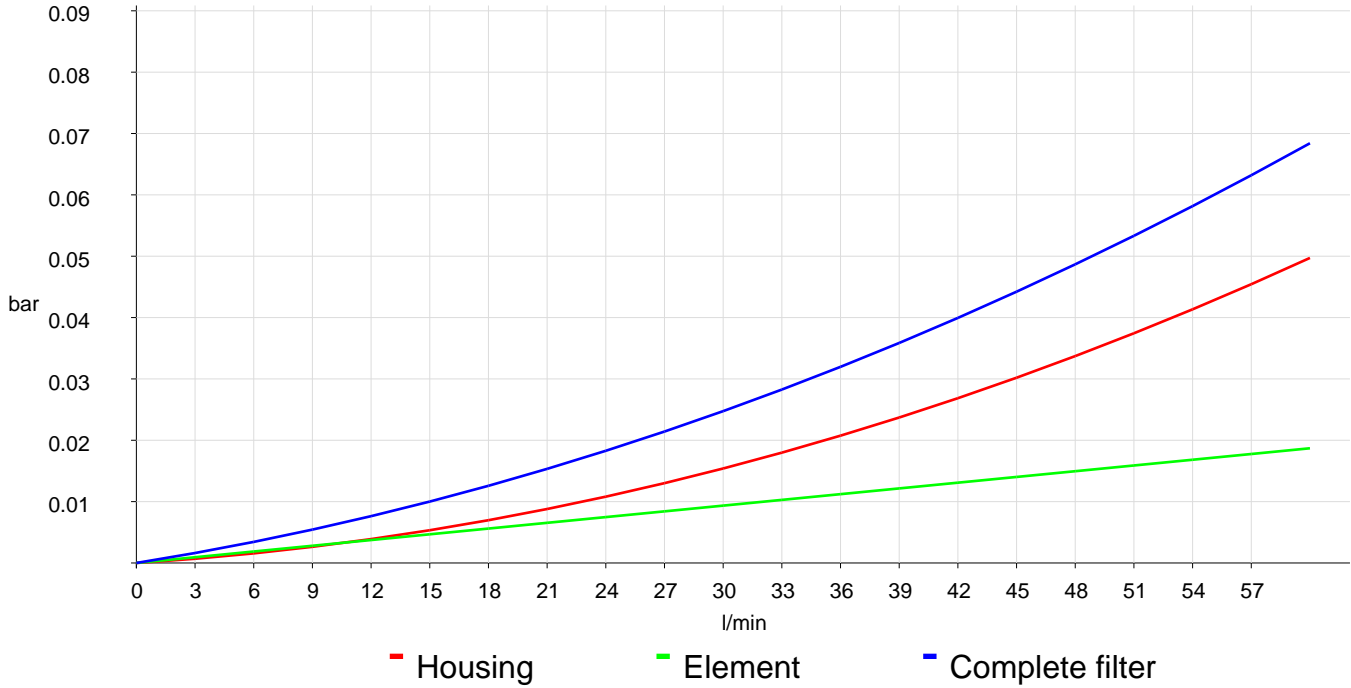
Description

Machine

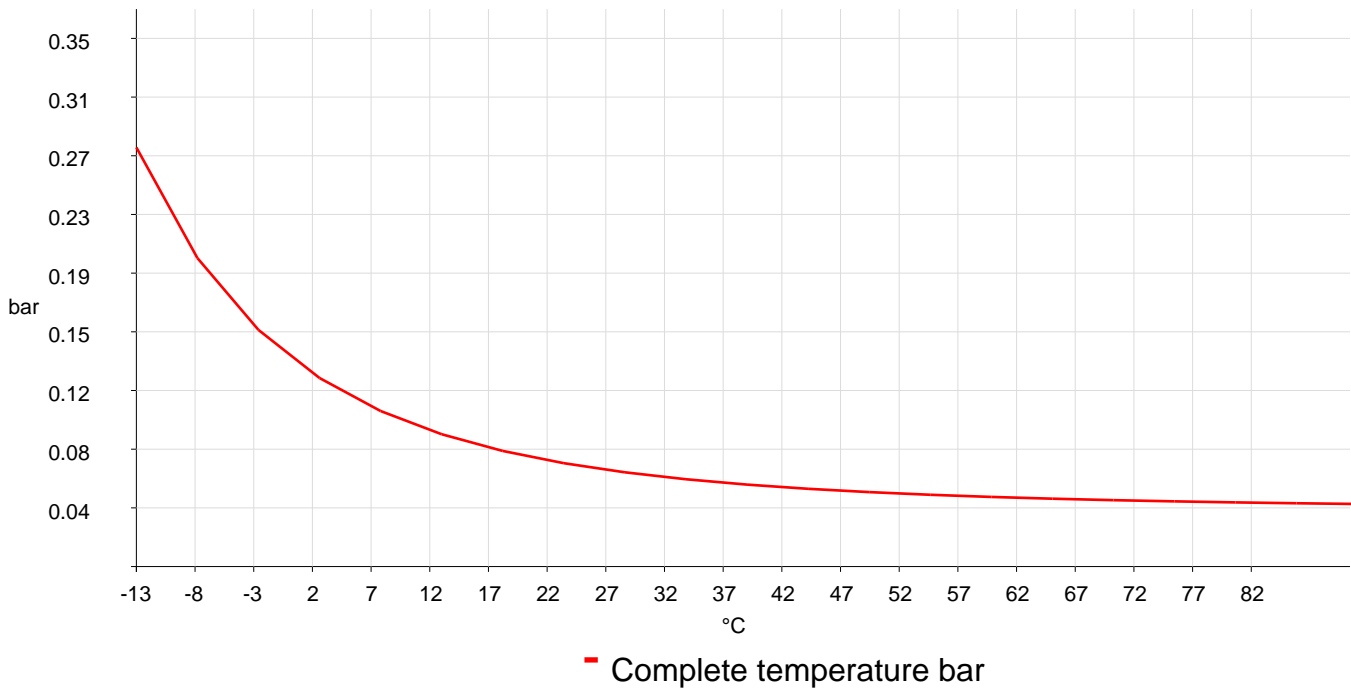
Author

Project

Delta P/Q (Viscosity: 22 cst)



Delta P/T (Flow rate: 50 l/min)



Prilog 5: Pužni vijak i kolo

Schneckenradsätze

Worm gear units

DIN 3975/ 3976

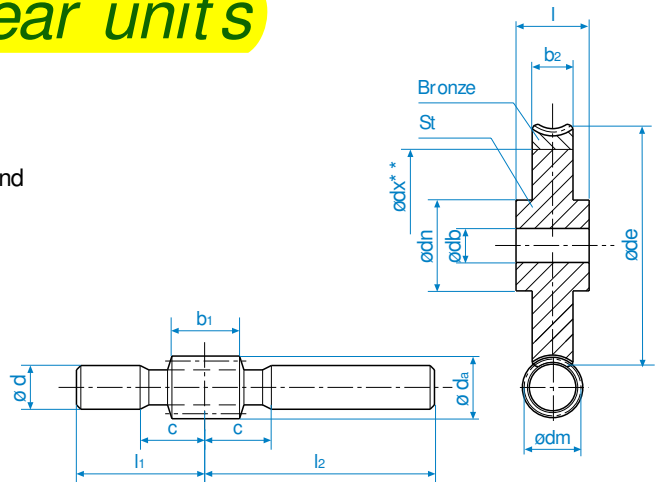
Gearing right hand
Worm
171 - - - - -
hardened/ ground

172 - - - - -
not hardened
not ground
Steel: 1.7131
(16 MnCr 5)

DIN 3975/ 3976

Verzahnung rechtssteigend
Schneckenwelle
171 - - - - -
gehärtet/ geschliffen

172 - - - - -
nicht gehärtet
nicht geschliffen
Stahl: 1.7131
(16 MnCr 5)



Achsabstand

125 mm

Centre distance

i	Modul Module	z_1^*	d_m	d_a	d	c	l_1	l_2	b_1	[kg]	Bestell Nr. Part No.	Bestell Nr. Part No.
7,25:1	6,3	4	63	75,6	47,5	50	150	250	86	6,52	171-763-463	172-763-463
10,00:1	5	4	50	60	50	68	150	250	69	5,89	171-750-450	172-750-450
12,50:1	4	4	50	58	50	56	150	250	60	6,02	171-740-450	172-740-450
14,50:1	6,3	2	63	75,6	50	68	150	250	86	6,91	171-763-263	172-763-263
20,00:1	5	2	50	60	50	56	150	250	69	5,99	171-750-250	172-750-250
25,00:1	4	2	50	58	50	56	150	250	60	6,02	171-740-250	172-740-250
29,00:1	6,3	1	63	75,6	50	62	150	250	86	6,89	171-763-163	172-763-163
40,00:1	5	1	50	60	50	56	150	250	69	5,99	171-750-150	172-750-150
50,00:1	4	1	50	58	50	56	150	250	60	6,02	171-740-150	172-740-150
62,00:1	3,15	1	53	59,3	50	50	150	250	60	6,19	171-731-153	172-731-153
83,00:1	2,5	1	42,5	47,5	47	50	150	250	50	5,18	171-725-142	172-725-142

Worm wheel

176 - - - - -
Specialbronze **
Hub: Steel

175 - - - - -
Cast iron

Schneckenrad

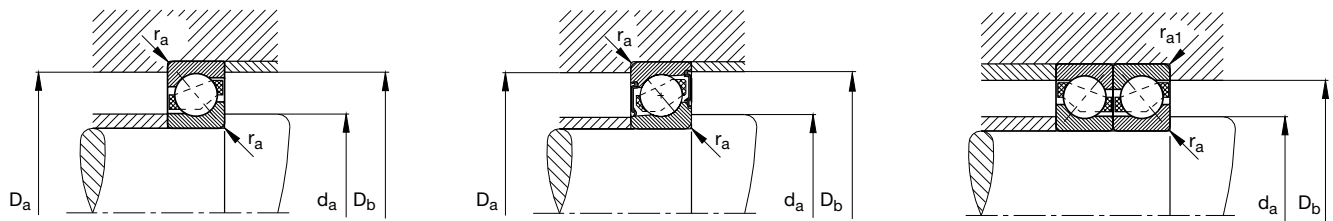
176 - - - - -
Spezialbronze **
Nabe: Stahl

175 - - - - -
Grauguß

i	Modul Module	z_1^*	z^*	d_e	d_n	d_b	d_x^{**}	b_2	l	[kg]	Bestell Nr. Part No.	[kg]	Bestell Nr. Part No.
7,25:1	6,3	4	29	206	100	50	148	50	60	11,33	176-763-429	9,87	175-763-429
10,00:1	5	4	40	215	100	50	170	40	60	11,05	176-750-440	9,61	175-750-440
12,50:1	4	4	50	212	100	50	174	34	60	10,25	176-740-450	8,93	175-740-450
14,50:1	6,3	2	29	206	100	50	148	50	60	11,33	176-763-229	9,87	175-763-229
20,00:1	5	2	40	215	100	50	170	40	60	11,05	176-750-240	9,61	175-750-240
25,00:1	4	2	50	212	100	50	174	34	60	10,25	176-740-250	8,93	175-740-250
29,00:1	6,3	1	29	206	100	50	148	50	60	11,33	176-763-129	9,87	175-763-129
40,00:1	5	1	40	215	100	50	170	40	60	11,05	176-750-140	9,61	175-750-140
50,00:1	4	1	50	212	100	50	174	34	60	10,25	176-740-150	8,93	175-740-150
62,00:1	3,15	1	62	206,5	100	50	174	34	60	9,55	176-731-162	8,32	175-731-162
83,00:1	2,5	1	83	215	100	50	186	28	60	9,19	176-725-183	7,95	175-725-183

* z_1^* : Zähne - Gangzahl/ Number of teeth - threads; d_x^{**} ca. \emptyset St/ Bronze; i = Übersetzungsverh/ ratio

Prilog 6: FAG ležajevi



Fatigue limit load C_{ur}	Limiting speed	Reference speed	Designation	Mounting dimensions				
				Bearing	d_a min	D_a max	D_b max	r_a max
N	min^{-1}		FAG	mm				
475	18000		7004B.TVP	23.2	38.8	40	0.6	0.3
475	9500		7004B.2RS.TVP	23.2	38.8	40	0.6	0.3
530	18000	18000	7204B.TVP	25.6	41.4	42.8	1	0.6
530	18000	18000	7204B.JP	25.6	41.4	42.8	1	0.6
530	28000	18000	7204B.MP	25.6	41.4	42.8	1	0.6
530	9000		7204B.2RS.TVP	25.6	41.4	42.8	1	0.6
750	17000	13000	7304B.TVP	27	45	47.8	1	0.6
750	17000	13000	7304B.JP	27	45	47.8	1	0.6
680	28000	14000	7304B.MP	27	45	47.8	1	0.6
750	8500		7304B.2RS.TVP	27	45	47.8	1	0.6
590	16000		7005B.TVP	28.2	43.8	45	0.6	0.3
590	8000		7005B.2RS.TVP	28.2	43.8	45	0.6	0.3
610	16000	16000	7205B.TVP	30.6	46.4	47.8	1	0.6
610	16000	16000	7205B.JP	30.6	46.4	47.8	1	0.6
570	26000	16000	7205B.MP	30.6	46.4	47.8	1	0.6
610	8000		7205B.2RS.TVP	30.6	46.4	47.8	1	0.6
1070	14000	11000	7305B.TVP	32	55	57.8	1	0.6
1070	14000	11000	7305B.JP	32	55	57.8	1	0.6
960	22000	12000	7305B.MP	32	55	57.8	1	0.6
1070	7000		7305B.2RS.TVP	32	55	57.8	1	0.6
780	14000		7006B.TVP	34.6	50.4	51.8	1	0.6
780	6700		7006B.2RS.TVP	34.6	50.4	51.8	1	0.6
960	13000	13000	7206B.TVP	35.6	56.4	57.8	1	0.6
960	13000	13000	7206B.JP	35.6	56.4	57.8	1	0.6
890	20000	14000	7206B.MP	35.6	56.4	57.8	1	0.6
960	6300		7206B.2RS.TVP	35.6	56.4	57.8	1	0.6
1500	11000	10000	7306B.TVP	37	65	67.8	1	0.6
1500	11000	10000	7306B.JP	37	65	67.8	1	0.6
1360	18000	10000	7306B.MP	37	65	67.8	1	0.6
1500	6000		7306B.2RS.TVP	37	65	67.8	1	0.6

Other designs are also available; please contact us.

Prilog 7: Hidromotor MP32

SPECIFICATION DATA

Specification Data for MP... motors with **C, CO, SH, K** and **SA** shafts.
(ø28,56 sealing diameter)

Type	MP 25	MP 32	MP 40	MP 50	MP 80	MP 100	MP 125	
Displacement, cm³/rev [in³/rev]	25 [1.52]	32 [1.95]	40 [2.44]	49,5 [3.02]	79,2 [4.83]	99 [6.04]	123,8 [7.55]	
Max. Speed, [RPM]	Cont.	1560	1500	1210	755	605	486	
	Int.*	1815	1720	1750	1515	945	605	
Max. Torque daNm [lb-in]	Cont.	3,3 [290]	4,3 [380]	6,2 [550]	9,4 [835]	15,1 [1340]	19,3 [1710]	23,7 [2100]
	Int.*	4,7 [415]	6,1 [540]	8,2 [730]	11,9 [1050]	19,5 [1725]	23,7 [2100]	29,8 [2640]
	Peak**	6,7 [595]	8,6 [760]	10,7 [950]	14,3 [1285]	22,4 [1985]	27,5 [2435]	36,5 [3235]
Max. Output kW [HP]	Cont.	4,5 [6.0]	5,8 [7.8]	8,4 [11.5]	10,1 [13.5]	10,2 [13.7]	10,5 [14.1]	10,2 [13.7]
	Int.*	6,1 [8.2]	7,8 [10.5]	11,6 [15.5]	12,2 [16.1]	12,5 [16.8]	12,8 [17.1]	12 [16.1]
Max. Pressure Drop bar [PSI]	Cont.	100 [1450]	100 [1450]	120 [1750]	140 [2030]	140 [2030]	140 [2030]	140 [2030]
	Int.*	140 [2030]	140 [2030]	155 [2250]	175 [2540]	175 [2540]	175 [2540]	175 [2540]
	Peak**	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]
Max. Oil Flow lpm [GPM]	Cont.	40 [10.5]	50 [13.2]	60 [15.9]	60 [15.9]	60 [15.9]	60 [15.9]	60 [15.9]
	Int.*	45 [11.9]	55 [14.5]	70 [18.5]	75 [19.8]	75 [19.8]	75 [19.8]	75 [19.8]
Max. Inlet Pressure bar [PSI]	Cont.	175 [2540]	175 [2540]	175 [2540]	175 [2540]	175 [2540]	175 [2540]	175 [2540]
	Int.*	200 [2900]	200 [2900]	200 [2900]	200 [2900]	200 [2900]	200 [2900]	200 [2900]
	Peak**	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]
Max. Return Pressure with Drain Line bar [PSI]	Cont.	175 [2540]	175 [2540]	175 [2540]	175 [2540]	175 [2540]	175 [2540]	175 [2540]
	Int.*	200 [2900]	200 [2900]	200 [2900]	200 [2900]	200 [2900]	200 [2900]	200 [2900]
	Peak**	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]	225 [3260]
Max. Starting Pressure with Unloaded Shaft, bar [PSI]	10 [145]	10 [145]	10 [145]	10 [145]	10 [145]	10 [145]	9 [131]	
Min. Starting Torque daNm [lb-in]	At max.press. drop Cont.	3,0 [265]	4,0 [355]	5,4 [480]	7,8 [690]	13,2 [1170]	16,6 [1470]	20,7 [1830]
	At max.press. drop Int.*	4,2 [370]	5,6 [500]	6,8 [600]	10 [885]	16,8 [1490]	21 [1860]	26,6 [2360]
Min. Speed***, [RPM]	20	15	10	10	10	10	10	
Weight, kg [lb] For rear ports +0,450 [.992]	MP(F)(N)	5,6 [12.3]	5,6 [12.3]	5,7 [12.6]	5,8 [12.8]	5,9 [13.2]	6,1 [13.5]	6,2 [13.7]
	MPW(N)	5,3 [11.7]	5,3 [11.7]	5,4 [11.9]	5,5 [12.1]	5,6 [12.4]	5,8 [12.8]	5,9 [13]
	MPQ(N)	5,0 [11.1]	5,0 [11.1]	5,1 [11.2]	5,2 [11.5]	5,3 [11.7]	5,5 [12.1]	5,6 [12.3]

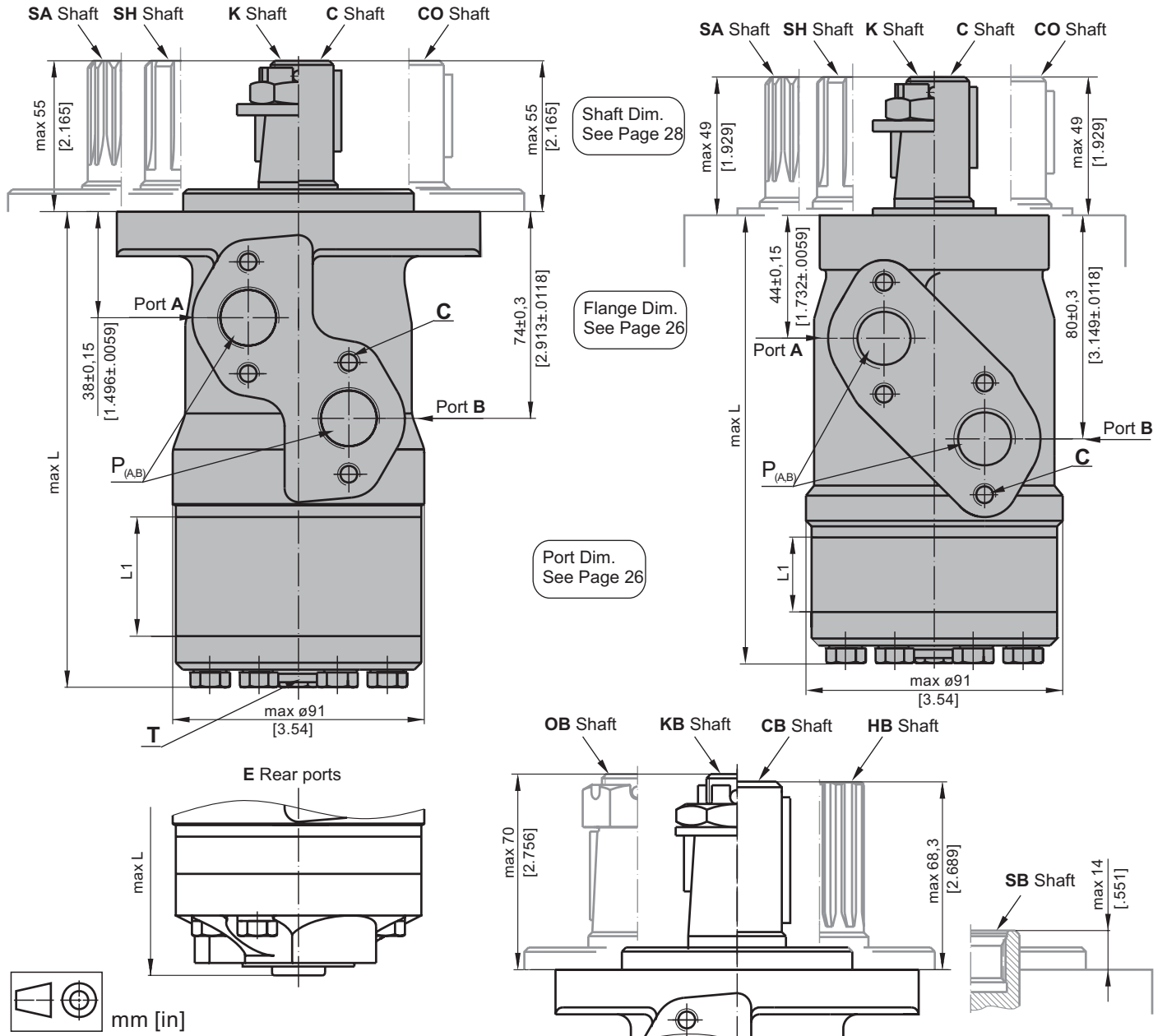
* Intermittent operation: the permissible values may occur for max. 10% of every minute.

** Peak load: the permissible values may occur for max. 1% of every minute.

*** For speeds lower than given, consult factory or your regional manager.

- Intermittent speed and intermittent pressure must not occur simultaneously.
- Recommended filtration is per ISO cleanliness code 20/16. A nominal filtration of 25 micron or better.
- Recommend using a premium quality, anti-wear type mineral based hydraulic oil HLP(DIN51524) or HM (ISO 6743/4).
If using synthetic fluids consult the factory for alternative seal materials.
- Recommended minimum oil viscosity 13mm²/s [70 SUS] at 50°C [122°F].
- Recommended maximum system operating temperature is 82°C [180°F].
- To assure optimum motor life fill with fluid prior to loading and run at moderate load and speed for 10-15 minutes.

DIMENSIONS AND MOUNTING DATA



C : 4xM8 - 13 mm [.51 in] depth
P_(A,B) : 2xG1/2 or 2xM22x1,5 - 15 mm [.59 in] depth
T : G1/4 or M14x1,5 - 12 mm [.47 in] depth (plugged)

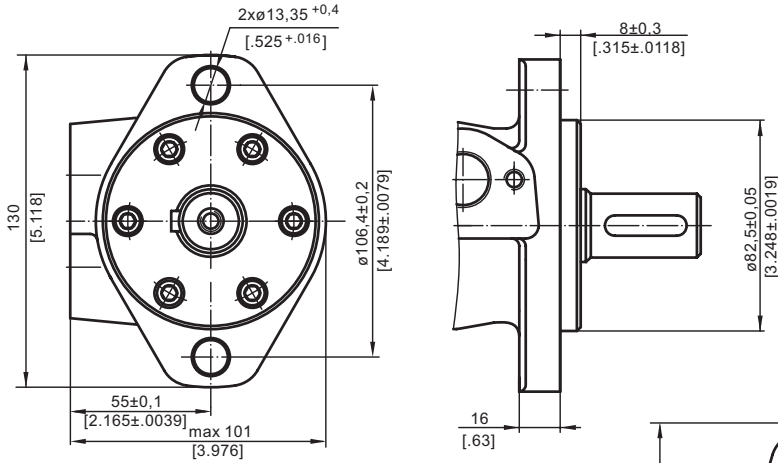
Standard Rotation
 Viewed from Shaft End
 Port A Pressurized - **CW**
 Port B Pressurized - **CCW**

Reverse Rotation
 Viewed from Shaft End
 Port A Pressurized - **CCW**
 Port B Pressurized - **CW**

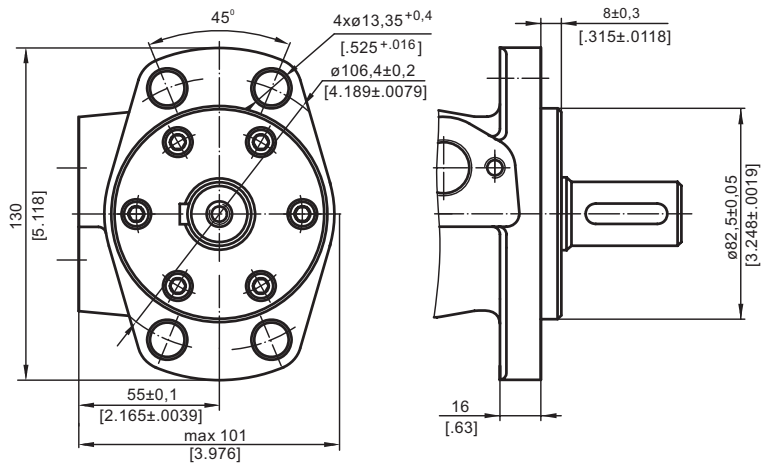
Type	L, mm [in]	Type	L, mm [in]	Type	L, mm [in]	Type	L, mm [in]	L _r , mm [in]
MP(F) 25	134,0 [5.28]	MPQ 25	140,5 [5.53]	MP(F)E 25	151,5 [5.96]	MPQE 25	158,0 [6.22]	5,20 [.21]
MP(F) 32	135,0 [5.31]	MPQ 32	141,5 [5.57]	MP(F)E 32	152,5 [6.00]	MPQE 32	159,0 [6.26]	6,30 [.25]
MP(F) 40	136,5 [5.37]	MPQ 40	142,5 [5.61]	MP(F)E 40	154,0 [6.06]	MPQE 40	160,0 [6.30]	7,40 [.29]
MP(F) 50	135,5 [5.33]	MPQ 50	142,0 [5.59]	MP(F)E 50	153,0 [6.02]	MPQE 50	159,5 [6.28]	6,67 [.26]
MP(F) 80	139,5 [5.49]	MPQ 80	146,0 [5.75]	MP(F)E 80	157,0 [6.18]	MPQE 80	163,0 [6.42]	10,67 [.42]
MP(F) 100	142,0 [5.59]	MPQ 100	148,5 [5.85]	MP(F)E 100	160,0 [6.30]	MPQE 100	166,0 [6.54]	13,33 [.52]
MP(F) 125	145,5 [5.73]	MPQ 125	152,0 [5.98]	MP(F)E 125	163,0 [6.42]	MPQE 125	169,5 [6.67]	16,67 [.66]
MP(F) 160	150,0 [5.91]	MPQ 160	156,5 [6.16]	MP(F)E 160	168,0 [6.61]	MPQE 160	174,0 [6.85]	21,33 [.84]
MP(F) 200	155,5 [6.12]	MPQ 200	162,0 [6.38]	MP(F)E 200	173,0 [6.81]	MPQE 200	179,5 [7.07]	26,67 [1.05]
MP(F) 250	162,0 [6.38]	MPQ 250	168,5 [6.63]	MP(F)E 250	180,0 [7.09]	MPQE 250	186,0 [7.32]	33,33 [1.31]
MP(F) 315	171,5 [6.75]	MPQ 315	178,0 [7.01]	MP(F)E 315	189,0 [7.44]	MPQE 315	195,5 [7.70]	42,67 [1.68]
MP(F) 400	182,0 [7.17]	MPQ 400	188,5 [7.42]	MP(F)E 400	200,0 [7.87]	MPQE 400	206,0 [8.11]	53,33 [2.10]
MP(F) 500	195,5 [7.70]	MPQ 500	202,0 [7.95]	MP(F)E 500	213,0 [8.39]	MPQE 500	219,5 [8.64]	66,63 [2.62]
MP(F) 630	213,0 [8.39]	MPQ 630	219,0 [8.62]	MP(F)E 630	230,5 [9.07]	MPQE 630	236,5 [9.31]	84,00 [3.31]

MOUNTING

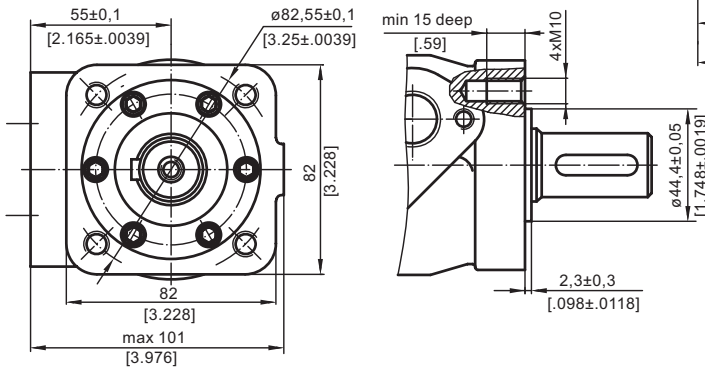
Oval Mount (2 Holes)



F - Oval Mount (4 Holes)

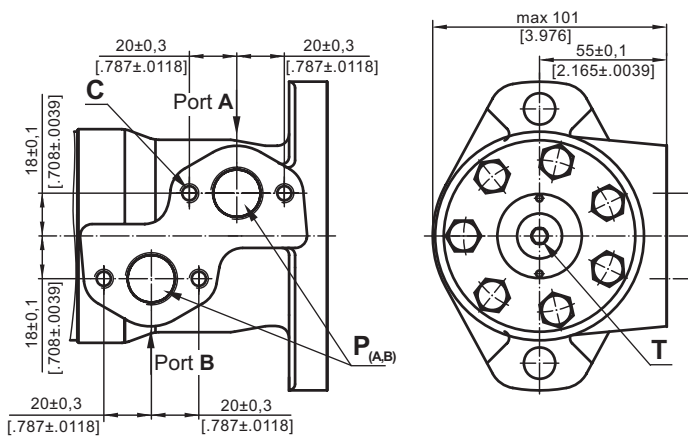


Q - Square Mount (4 Bolts)

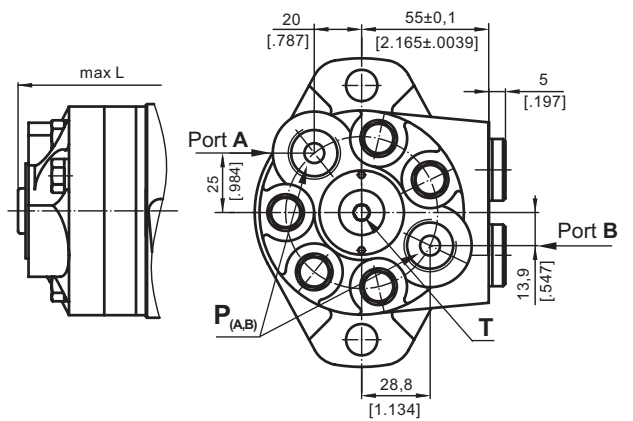


PORTS

Side Ports



E Rear Ports



- C** : 4xM8 - 13 mm [.51 in] depth
- P_(A,B)** : 2xG1/2 or 2xM22x1,5 - 15 mm [.59 in] depth
- T** : G1/4 or M14x1,5 - 12 mm [.47 in] depth (plugged)

- Standard Rotation**
Viewed from Shaft End
Port A Pressurized - CW
Port B Pressurized - CCW

- Reverse Rotation**
Viewed from Shaft End
Port A Pressurized - CCW
Port B Pressurized - CW

Prilog 8: Razvodnik PVG32

General description

PVG 32 is a hydraulic load sensing valve designed to give maximum flexibility. From a simple load sensing directional valve, to an advanced electrically controlled load-independent proportional valve.

The PVG 32 modular system makes it possible to build up a valve group to meet requirements precisely. The compact external dimensions of the valve remain unchanged whatever combination is specified.

Features of PVG 32

- Load-independent flow control:
 - Oil flow to an individual function is independent of the load pressure of this function
 - Oil flow to one function is independent of the load pressure of other functions
- Good regulation characteristics
- Energy-saving
- Up to 12 basic modules per valve group
- Several types of connection threads
- Low weight
- Compact design and installation



PVG modules

PVP, pump side modules

- Built-in pressure relief valve
- Pressure gauge connection
- Versions:
 - Open center version for systems with fixed displacement pumps
 - Closed center version for systems with variable displacement pumps
 - Pilot oil supply for electrical actuator built into the pump side module
 - Pilot oil supply for hydraulic actuation built into the pump side module
 - Versions prepared for electrical LS unloading valve PVPX

General description
PVB, basic modules

- Interchangeable spools
- Depending on requirements the basic module can be supplied with:
 - Integrated pressure compensator in channel P
 - Load holding check valve in channel P
 - Shock/suction valves for A and B ports
 - LS pressure limiting valves individually adjustable for ports A and B
 - Different interchangeable spool variants
 - All versions suitable for mechanical, hydraulic and electrical actuation

Actuation modules

The basic module is always fitted with mechanical actuator PVM and PVMD, which can be combined with the following as required:

- **Electrical actuator (11 - 32 V ===):**
 - PVES – proportional, Super
 - **PVEH – proportional, High performance**
 - PVEH-F – proportional high performance, Float
 - PVEA – proportional low hysteresis
 - PVEM – proportional, Medium performance
 - PVEO – ON/OFF
 - PVEU – proportional, voltage control, 0-10 V
 - PVED-CC – Digital CAN controlled J1939/ISOBUS
 - PVED-CX – Digital CAN controlled CANopen X-tra safety
 - PVEP – PWM voltage controlled (11-32 V)
 - PVHC – High Current actuator for PVG
- PVMR, cover for Mechanical detent
- PVMF, cover for Mechanical Float
- PVH, cover for Hydraulic actuation

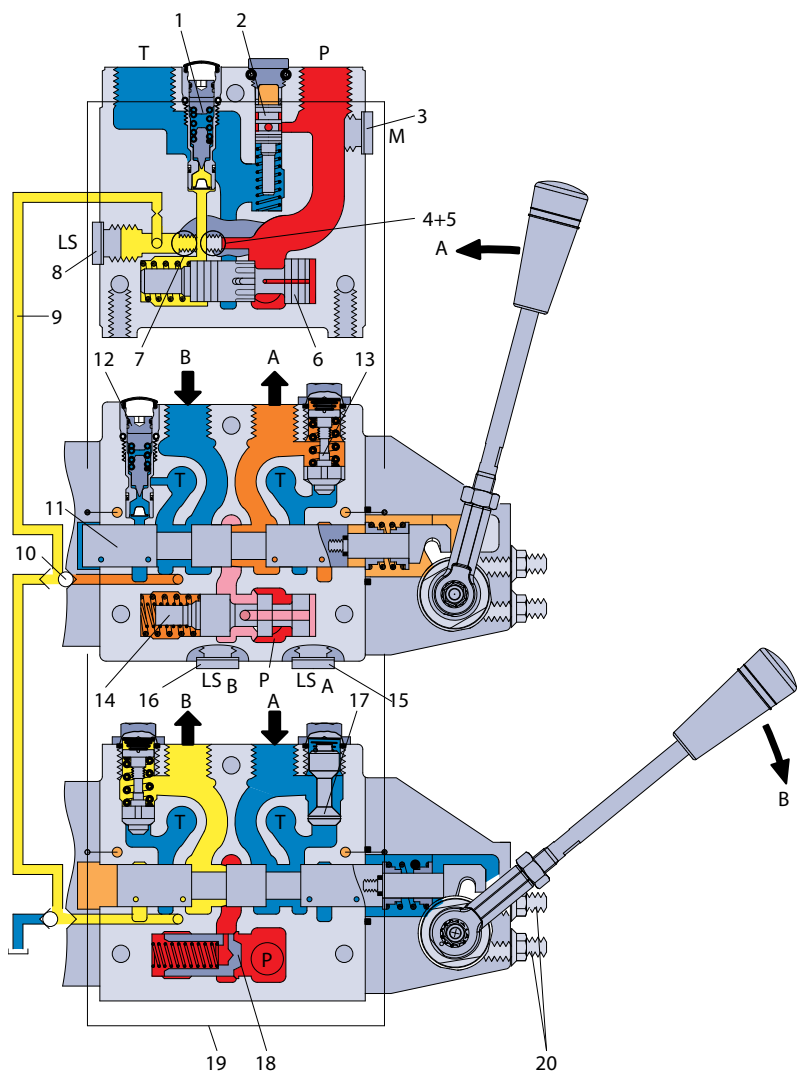
Remote control units

- Electrical remote control units:

– PVRE, PVRET	– JS1000 Ball grip
– PVREL	– JS1000 PRO grip
– PVRES	– JS2000
– Prof 1	– JS6000
– Prof 1 CIP	– JS7000
– JS120	
- Hydraulic remote control unit: PVRHH

General description

PVG 32 sectional drawing



V310106.A

- | | |
|---|--|
| 1 – Pressure relief valve | 11 – Main spool |
| 2 – Pressure reduction valve for pilot oil supply | 12 – LS pressure limiting valve |
| 3 – Pressure gauge connection | 13 – Shock and suction valve, PVLP |
| 4 – Plug, open center | 14 – Pressure compensator |
| 5 – Orifice, closed center | 15 – LS connection, port A |
| 6 – Pressure adjustment spool | 16 – LS connection, port B |
| 7 – Plug, closed center | 17 – Suction valve, PVLA |
| 8 – LS connection | 18 – Load drop check valve |
| 9 – LS signal | 19 – Pilot oil supply for PVE |
| 10 – Shuttle valve | 20 – Max. oil flow adjustment screws for A/B ports |

General description

Load sensing for variable displ. pump supply

The pump receives fluid directly from the reservoir through the inlet line. A screen in the inlet line protects the pump from large contaminants.

The pump outlet feeds directional control valves such as PVG-32, hydraulic integrated circuits (HIC), and other types of control valves.

The PVG valve directs and controls pump flow to cylinders, motors and other work functions. A heat exchanger cools the fluid returning from the valve. A filter cleans the fluid before it returns to the reservoir.

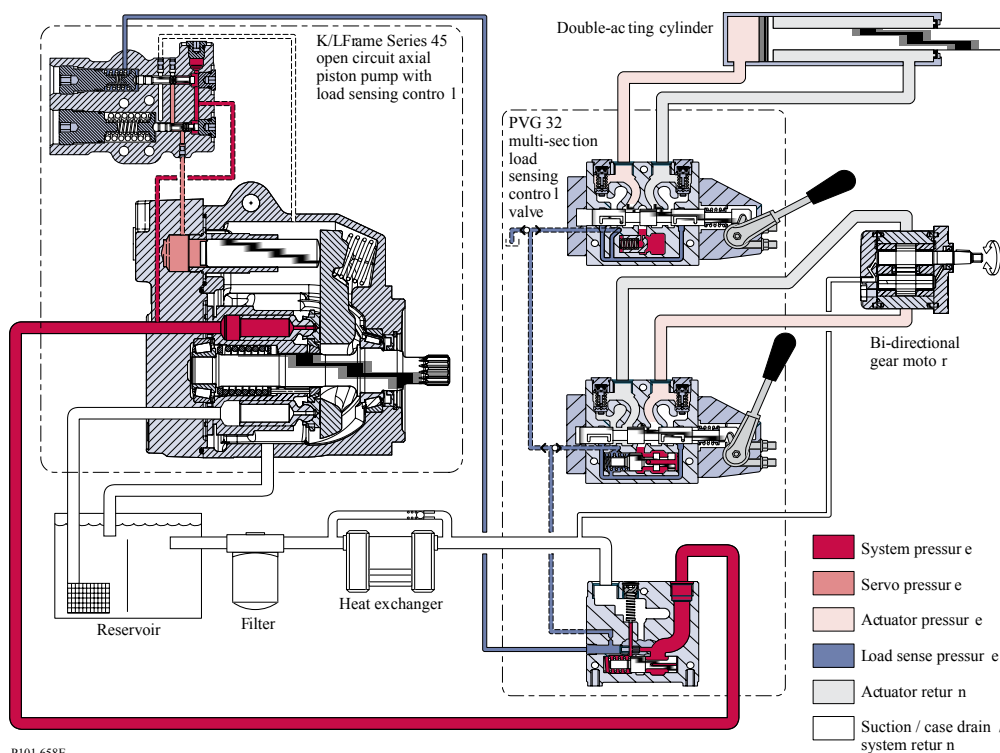
Flow in the circuit determines the speed of the actuators. The position of the PVG valve spool determines the flow demand. A hydraulic pressure signal (LS signal) communicates demand to the pump control.

The pump control monitors the pressure differential between pump outlet and the LS signal, and regulates servo pressure to control the swashplate angle. Swashplate angle determines pump flow.

Actuator load determines system pressure. The pump control monitors system pressure and will decrease the swashplate angle to reduce flow if system pressure reaches the pump control setting.

A secondary system relief valve in the PVG valve acts as a back-up to control system pressure.

Pictorial circuit diagram



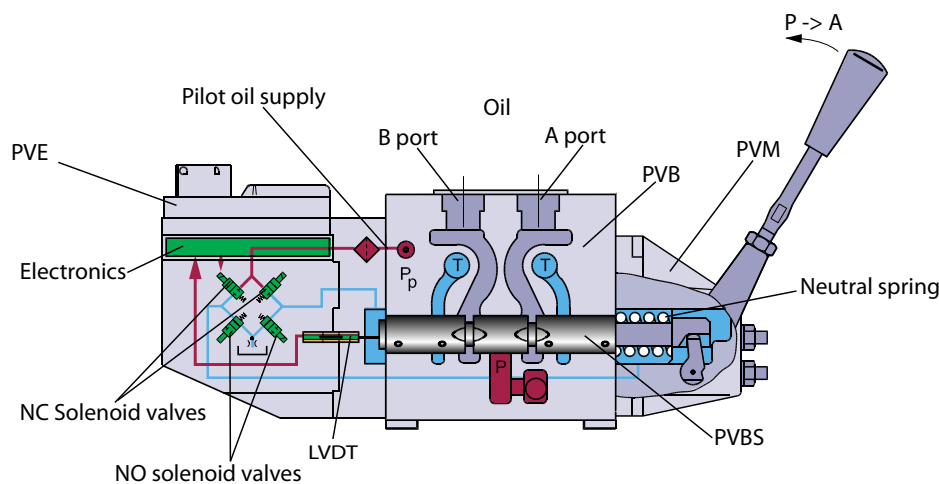
Electrical actuation
Electrical control of PVG

Valve actuation with electrical actuators has been supported by Danfoss for a long time. The actuation can be controlled directly by joystick, by a PLUS+1® controller or by a broad range of third part controllers. The actuator controls the spool by building up pilot oil pressure on the end of the spool. For the PVE a pilot oil pressure between 10 and 15 bar is used. For the PVHC a pilot oil pressure between 20 and 25 bar is used.

PVG with PVE



Valve section with naming - standard mounted - seen from PVP



V310072.B

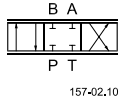
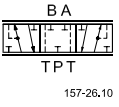
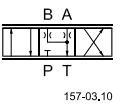
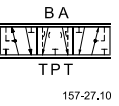
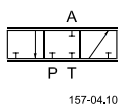
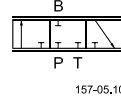
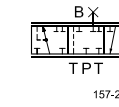
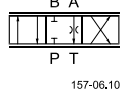
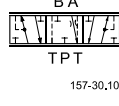
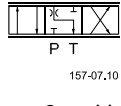
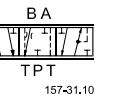
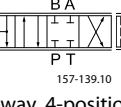
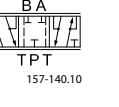
A detailed description of the variants is presented in:

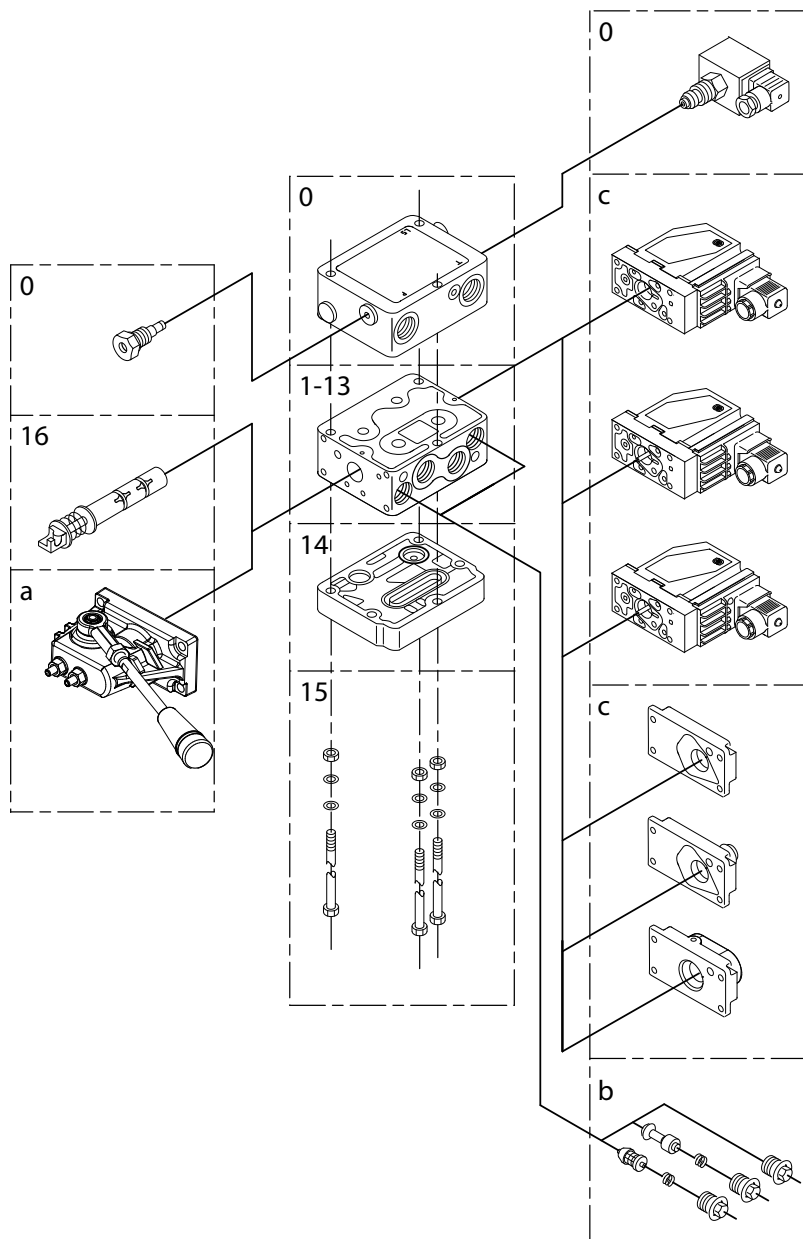
PVE-Series 4 for PVG 32, PVG 100 and PVG 120 Technical Information, 520L0553, covers all analogue PVE – PVEO, PVEH, PVES, PVEA, PVEM, PVEU, PVEP and the current controlled PVHC.

Electrohydraulic Actuator – PVED-CC Series 4 Technical Information, 520L0665, covers the ISOBUS/SAE J1939 CAN controlled PVED-CC.

Electrohydraulic Actuator – PVED-CX Series 4 Technical Information, 11070179, covers the IEC61508 SIL2 certified CANopen controlled PVED-CX.

Module selection chart
Standard FC spools

PVB is with LS _{A/B} shuttle valve							Code number 157B....	PVB is without LS _{A/B} shuttle valve							
Press. compensated flow: l/min [US gal/min]							ISO symbol	Symbol	Press. compensated flow l/min [US gal/min]						
F	E	D	C	B	A	AA			AA	A	B	C	D	E	F
130 [34.3]	100 [26.4]	65 [17.2]	40 [10.6]	25 [6.6]	10 [2.6]	5 [1.3]			5 [1.3]	10 [2.6]	25 [6.6]	40 [10.6]	65 [17.2]	100 [26.4]	130 [34.3]
7026	7024	7023	7022	7021	7020	7025	 157-02.10	 157-26.10	7005	7000	7001	7002	7003	7004	7006
							4-way, 3-position Closed neutral position								
7126	7124	7123	7122	7121	7120	7125	 157-03.10	 157-27.10	7105	7100	7101	7102	7103	7104	7106
							4-way, 3-position Throttled, open neutral position								
-	-	-	-	-	-	-	 157-04.10	 157-28.10	-	7200	7201	7202	7203	7204	-
							3-way, 3-position Closed neutral position, P → A								
-	-	-	-	-	-	-	 157-05.10	 157-29.10	-	-	7301	7302	7303	7304	-
							3-way, 3-position Closed neutral position, P → B								
-	7424	7423	7422	7421	-	-	 157-06.10	 157-30.10	-	-	7401	7402	7403	7404	7406
							4-way, 3-position Throttled, A → T in neutral position								
-	7524	7523	7522	7521	-	-	 157-07.10	 157-31.10	-	-	7501	7502	7503	7504	-
							4-way, 3-position Throttled, B → T in neutral position								
-	7624	7623	7622	7621	7620	-	 157-139.10	 157-140.10	-	-	-	-	-	-	-
							4-way, 4-position Closed neutral position Float P → B → F								

Module selection chart
PVB, basic valves


V310168.A

PVB, basic valves

Description	No facilities for shock valves A and B		Facilities for shock valves A and B	
	G ½	7/8 - 14 UNF	G ½	7/8 - 14 UNF
Without compensator /check valve	157B6000	157B6400	157B6030	157B6430
With check valve	157B6100	157B6500	157B6130	157B6530
With check valve and LSA/B shuttle valve	-	-	157B6136	157B6536
With compensator valve	157B6200	157B6600	157B6230	157B6630

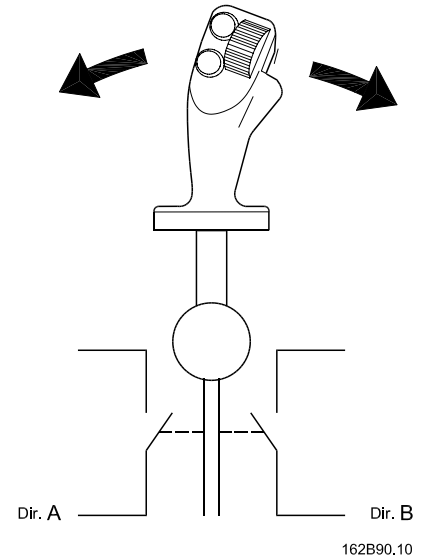
Prilog 9: Joystick PROF-1

Direction Switches

Proportional modules have integrated direction switches. One switch is activated when the module is moved in the A direction, the other is activated when the module is moved in the B direction.

The direction switches are used to activate the neutral position switch, and with some electronic modules the direction switch outputs are available in the connector. (See details about electronics.)

There is a dead band in the joystick of approximately 1.5° before the direction switches are activated.



Note: The direction switches are independent from the signal voltage

162B90.10

Neutral Position Switch

The neutral position switch can supply up to 3 PVEs or other devices (see electrical details), and functions as both a power save and a safety switch. The switch is only activated when one or more of the proportional modules are activated.

The operation of the neutral position switch is dependant on signals from the direction switches.

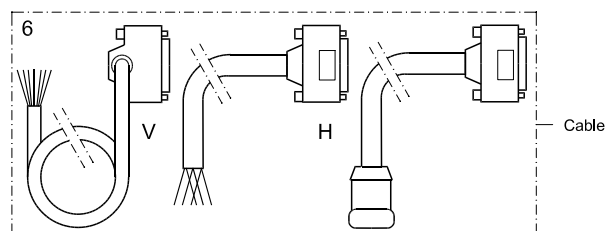
Sauer-Danfoss recommends that the neutral position switch be used to the greatest possible extent.

Note: When using the neutral position switch all three U_{DC} wires as well as all three Neutral Switch wires **must** be connected.

Cables

For compatibility with different applications, a selection of mating cables are available:

Code no. 162B....	Length mm [in]	Plug type	Type
6013	4000 [157]	Leads	Vertical SUB-D
6014	4000 [157]	Leads	Horizontal Sub-D
6015	500 [19]	Clipper	-
6016	230 [9]	TrimTrio	-
6017	230 [9]	Tabs	PVRE compatibility



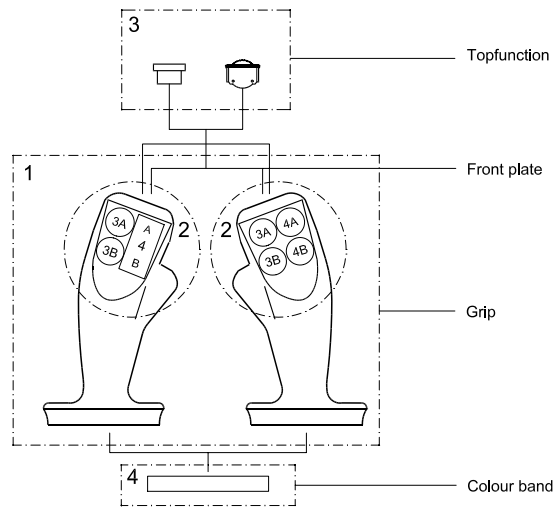
162B93.10 .10

Prof Joysticks

The Prof family of joysticks is built around a series of modules that can be combined in various ways to create the joystick that best fits the application. Each joystick has a base module with proportional functions (X & Y); a colour band for decoration and identity, a handle, and depending on handle selection, a number of pushbuttons and/or proportional functions.

Handle / Top functions

To provide optimum user comfort, a selection of handles is available. Each handle offers a choice of push buttons and / or proportional functions positioned for ease of use and comfort.



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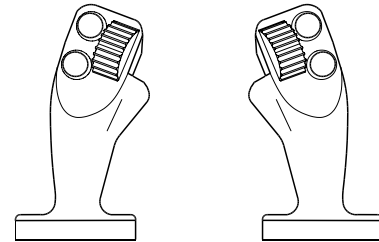
Prof 1

Prof 1

A professional handle for intensive operation; with a forward-leaning, curved, ergonomic shape. The leather-like grained surface allows the palm of the hand to breathe during operation.

The Prof 1 handle can be fitted with up to seven push buttons, or up to two proportional functions with up to five push buttons.

For location and combination of function modules see the overview.



LH

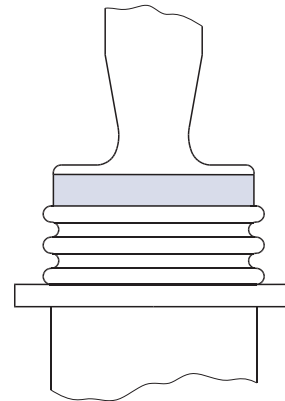
RH

162B94.10

Color Band

A choice of colors is available for the band at the base of the handle.

Colors
Yellow
Black
Red



162B08.10

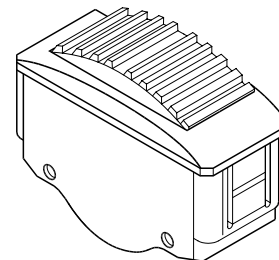
Proportional Modules

The roller function module is a spring centred potentiometer with integrated direction switches.

Working angle: $\pm 42^\circ$

Direction switch angle: $3.5 \pm 2^\circ$

Signal range	Neutral signal
25% – 75%	50%
of supply voltage	



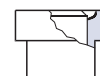
162B62.10

Push Buttons

The handle can be fitted with up to seven independent On/Off functions.

The buttons are protected against shocks and unintentional activation by a high collar.

Colors
Yellow
Black
Red
Grey



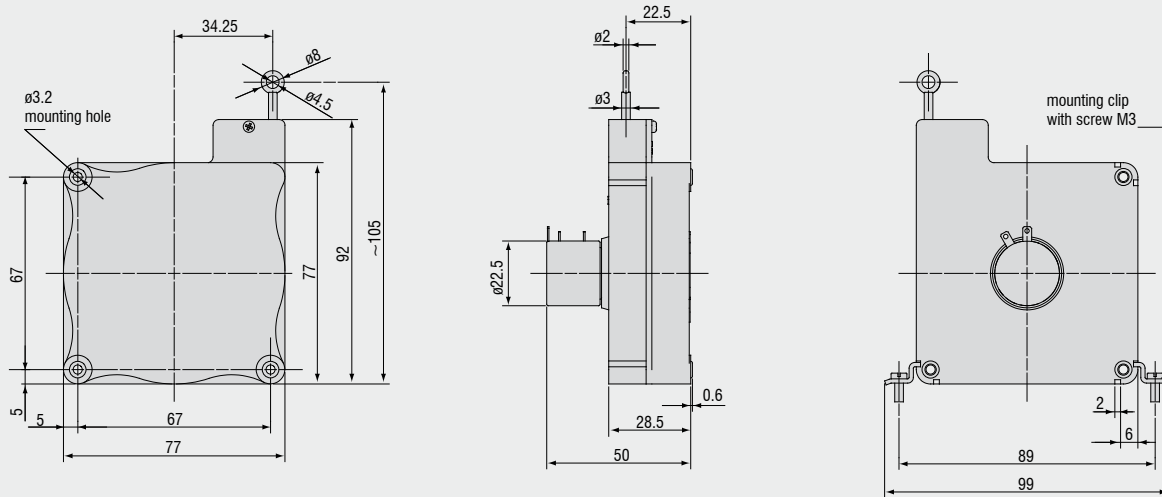
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Prilog 10: Senzor linearnog pomaka MK77

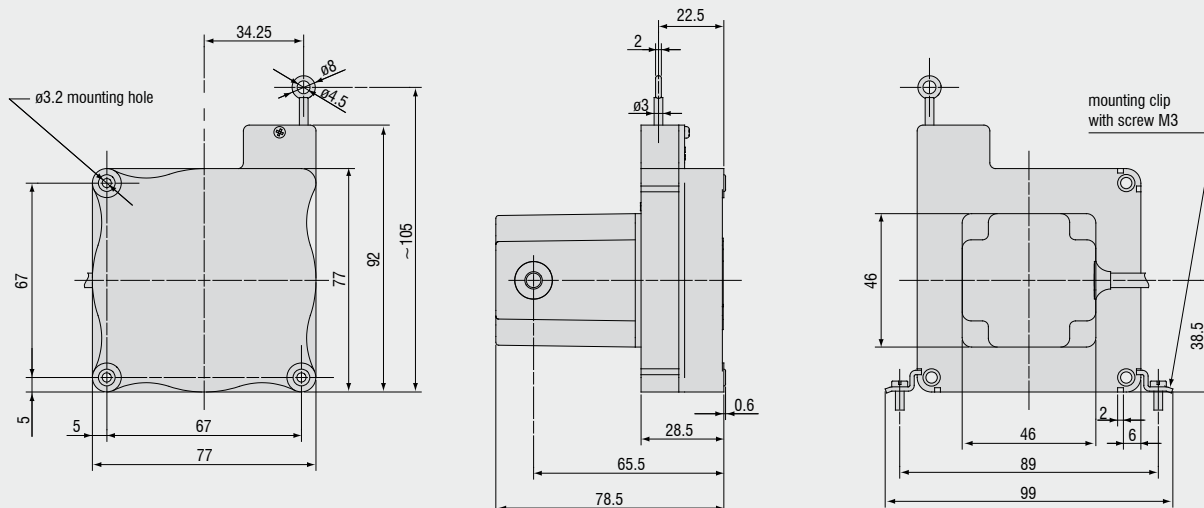


- Robust plastic housing
- Customized versions for OEM
- Wire potentiometer

Model MK77 Output P25



Model MK77 Output CR-P25



Model		WPS-2100-MK77	
Output			P25
Measuring range			2100mm
Linearity	wire pot.	<0.25% FSO	5.25mm
Resolution	wire pot.		0.55mm
Sensor element			wire potentiometer
Temperature range			-20 to 80°C
Material	housing		plastic
	draw wire		coated polyamid stainless steel
Wire mounting			eyelet
Sensor mounting			mounting holes / mounting grooves
Cable diameter			0.45mm
Wire retraction force (min)			3.5N
Wire extension force (max)			5N
Wire acceleration			5g
Protection class			IP 20
Electrical connection	P25		soldering tag
	CR-P25		integrated cable radial, 1m
Weight	P25		ca. 0.2kg
	CR-P25		ca. 0.25kg

FSO = Full Scale Output
 Specifications for analog outputs on page 47.

Article description

WPS - 2100 - MK77 - P25

Output option:
 potentiometer P25 (linearity <0.25% FSO)
 potentiometer CR-P25, integrated cable, radial, 1m

Model MK77

Measuring range in mm

Prilog 11: Rotacijski senzor RM36

RM36 series non-contact rotary encoders



The RM36 is a high-speed magnetic rotary encoder designed for use in harsh industrial environments. The non-contact two-part design removes the need for seals or bearings ensuring long-term reliability and simple installation.

The encoder comprises a magnetic actuator and a separate encoder body. Rotation of the magnetic actuator is sensed by a custom encoder chip within the body, and processed to the required output.

The encoder chip processes the signals received to provide resolutions to 13 bit (8,192 positions per revolution) with high operational speeds. Resolution options include binary and decimal. Output signals are provided in industry standard absolute, incremental or linear formats.

The compact encoder body is 36 mm in diameter and provides dirt immunity up to IP68.

The RM36 can be used in a wide range of applications including marine, medical, print, converting, industrial automation, metal working, motor control and instrumentation.

5 V power supply version

RM36I-incremental with 80 to 2,048 pulses per revolution (320 to 8,192 counts per revolution with x 4 evaluation)

RM36S-synchro serial interface (SSI) with 320 to 8,192 positions per revolution

24 V power supply version

RM36P-absolute parallel interface with 512 positions per revolution

RM36I-incremental with 80 to 2,048 pulses per revolution (320 to 8,192 counts per revolution with x 4 evaluation)

RM36V-linear voltage output in a range of variants

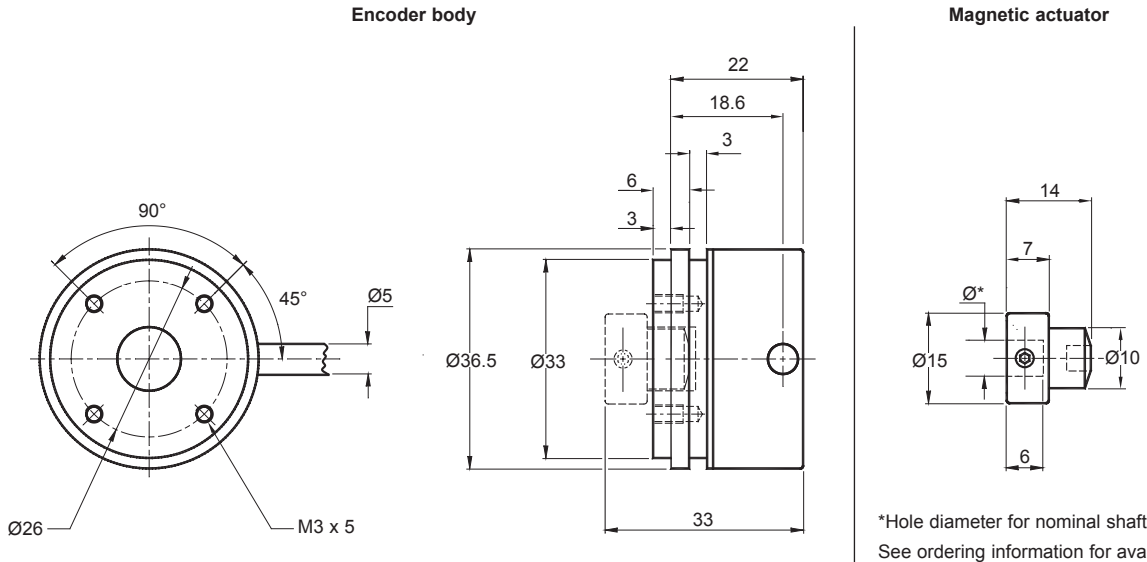
RM36C-linear current output in a range of variants

System features:

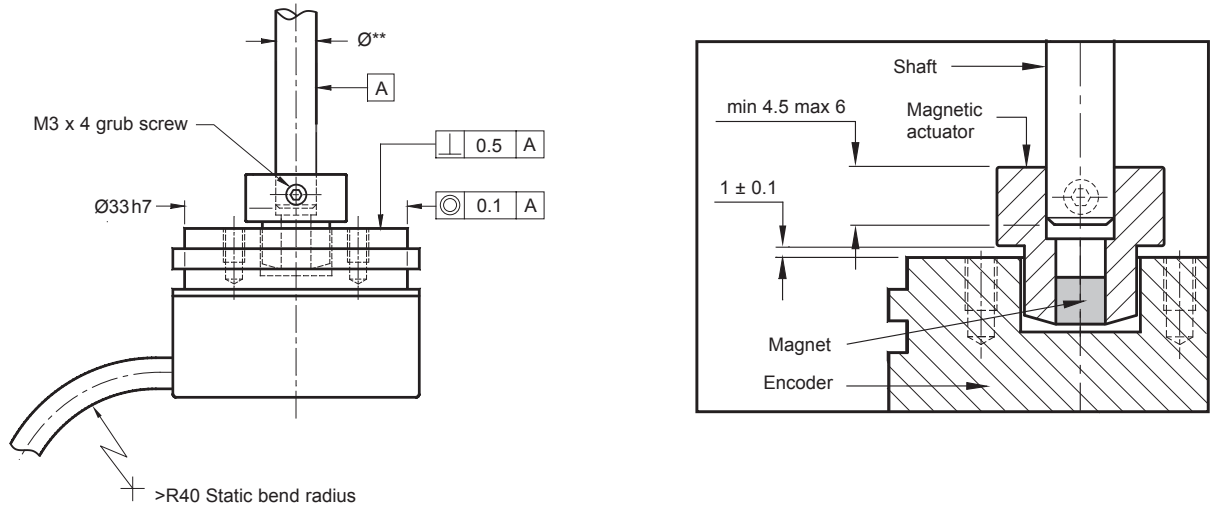
- Excellent immunity to IP68
- Non-contact, frictionless design
- High speed operation to 30,000 rpm
- 36 mm diameter body
- Industry standard absolute, incremental and linear output formats
- Binary and decimal resolution options
- Accuracy $\pm 0.5^\circ$
- Simple installation
- Low inertia
- Stainless steel body option

RM36 dimensions

Dimensions and tolerances in mm



RM36 installation drawing



**Nominal shaft size with tolerance h7.

Operating and electrical specifications

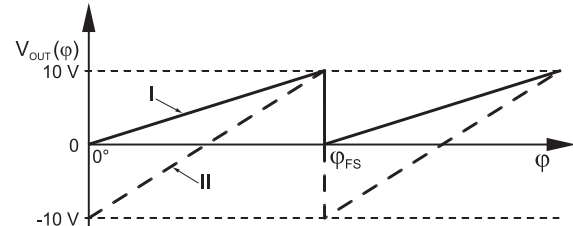
Humidity (for IP64 version)	Storage 95% maximum relative humidity (non-condensing) (IEC 61010-1) Operating 80% maximum relative humidity (non-condensing) (IEC 61010-1)
Acceleration	Operating 500 m/s ² BS EN 60068-2-7:1993 (IEC 68-2-7:1983)
Shock (non-operating)	1000 m/s ² , 6 ms, 1/2 sine BS EN 60068-2-27:1993 (IEC 68-2-27:1987)
Vibration (operating)	100 m/s ² max at 55 to 2000 Hz BS EN 60068-2-6:1996 (IEC 68-2-6:1995)
EMV compliance	BS EN 61326
Cable	Outside diameter 5 mm
Mass	Encoder unit 1 m cable (no connector) 85 g. Stainless steel variant 160 g. Magnetic actuator 12 g
Environmental sealing	IP64 (IP68 optional) BS EN 60529

Output specifications - 24 V supply

RM36V – Linear voltage output

Power supply	Type I: +20 V to +30 V DC Type II: ±12 V to ±16 V DC
Power consumption	40 mA typical
Output voltage	Type I: 0 V to 10 V DC Type II: -10 V to +10 V DC
Output loading	Max. 10 mA
Nonlinearity	1 %
Max. cable length	20 m
Connector options	9 pin 'D' type plug (standard) Flying lead
Temperature	Operating -25 °C to +70 °C Storage -25 °C to +125 °C
Maximum speed	30,000 rpm

Electrical output/shaft position



Output type and electrical variant

ϕ_{FS}	Type I				Type II			
	360°	180°	90°	45°	360°	180°	90°	45°
CW	VA	VB	VC	VD	VM	VN	VP	VQ
CCW	VE	VF	VG	VH	VR	VS	VT	VV

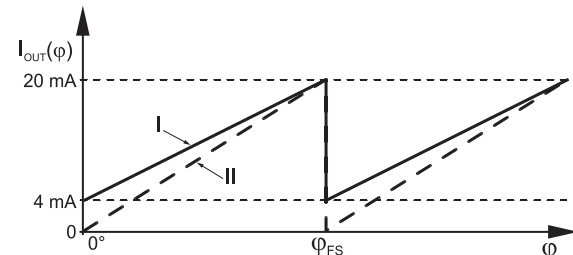


Image shows clockwise rotation of magnetic actuator

RM36C - Linear current output

Power supply	$V_{dd} = +20 \text{ V to } +30 \text{ V DC}$
Power consumption	50 mA plus output current
Output current	Type I: 4 mA to 20 mA Type II: 0 mA to 20 mA
Output loading	$R_L = 0 \text{ to } \frac{V_{dd}}{I_{OUTmax}}$
Nonlinearity	1 %
Max. cable length	20 m
Connector options	9 pin 'D' type plug (standard) Flying lead
Temperature	Operating -25 °C to +70 °C Storage -25 °C to +125 °C
Maximum speed	30,000 rpm

Electrical output/shaft position



Output type and electrical variant

ϕ_{FS}	Type I				Type II			
	360°	180°	90°	45°	360°	180°	90°	45°
CW	CA	CB	CC	CD	CM	CN	CP	CQ
CCW	CE	CF	CG	CH	CR	CS	CT	CV



Image shows clockwise rotation of magnetic actuator

Prilog 12: Senzor tlaka SITRANS P220 (7MF1567)

Pressure Measurement

Transmitters for basic requirements

SITRANS P220 for gauge pressure

Overview



The pressure transmitter SITRANS P220 measures the gauge pressure of liquids, gases and vapors.

- Stainless steel measuring cell, fully welded
- Measuring ranges 2.5 to 600 bar (36.3 to 8702 psi) relative
- For high-pressure applications and refrigeration technology division

Benefits

- High measuring accuracy
- Rugged stainless steel enclosure
- High overload withstand capability
- For aggressive and non-aggressive media
- For measuring the pressure of liquids, gases and vapors
- Compact design
- Gasket-less

Application

The pressure transmitter SITRANS P220 for gauge pressure is used in the following industrial areas:

- Mechanical engineering
- Shipbuilding
- Power engineering
- Chemical industry
- Water supply

Design

Device structure without explosion protection

The pressure transmitter consists of a piezoresistive measuring cell with a diaphragm installed in a stainless steel enclosure. It can be used with a connector per EN 175301-803-A (IP65), a round plug M12 (IP67), a cable (IP67) or a Quickon cable quick screw connection (IP67) connected electrically. The output signal is between 4 and 20 mA or 0 and 10 V.

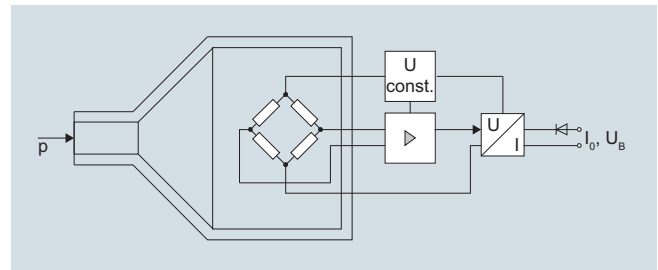
Device structure with explosion protection

The pressure transmitter consists of a piezoresistive measuring cell with a diaphragm installed in a stainless steel enclosure. It can be used with a connector per EN 175301-803-A (IP65) or a round plug M12 (IP67) connected electrically. The output signal is between 4 and 20 mA.

Function

The pressure transmitter measures the gauge pressure of liquids and gases as well as the level of liquids.

Mode of operation



SITRANS P220 pressure transmitters (7MF1567-...), functional diagram

The stainless steel measuring cell has a thick-film resistance bridge to which the operating pressure p is transmitted through a stainless steel diaphragm.

The voltage output from the measuring cell is converted by an amplifier into an output current of 4 to 20 mA or an output voltage of 0 to 10 V DC.

The output current and voltage are linearly proportional to the input pressure.

Technical specifications

Application	Gauge pressure measurement	Liquids, gases and vapors
Mode of operation	Measuring principle	Piezoresistive measuring cell (stainless steel diaphragm)
	Measured variable	Gauge pressure
Inputs	Measuring range	
	• Gauge pressure	
	- Metric	2.5 ... 600 bar (36 ... 8700 psi)
	- US measuring range	30... 8700 psi
Output	Current signal	4 ... 20 mA
	• Load	$(U_B - 10 \text{ V})/0.02 \text{ A}$
	• Auxiliary power U_B	DC 7 ... 33 V (10 ... 30 V for Ex)
	Voltage signal	0 ... 10 V DC
	• Load	$\geq 10 \text{ k}\Omega$
	• Auxiliary power U_B	12 ... 33 V DC
	• Power consumption	$< 7 \text{ mA}$ at 10 k Ω
	Characteristic curve	Linear rising
Measuring accuracy	Error in measurement at limit setting incl. hysteresis and reproducibility	<ul style="list-style-type: none"> • Typical: 0.25 % of full-scale value • Maximum: 0.5 % of full-scale value
	Step response time T_{99}	$< 5 \text{ ms}$
	Long-term stability	
	• Lower range value and measuring span	0.25 % of full-scale value/year
	Influence of ambient temperature	
	• Lower range value and measuring span	0.25 %/10 K of full-scale value
	• Influence of power supply	0.005 %/V
Conditions of use	• Process temperature	-30 ... +120 °C (-22 ... +248 °F)
	• Ambient temperature	-25 ... +85 °C (-13 ... +185 °F)
	• Storage temperature	-50 ... +100 °C (-58 ... +212 °F)
	• Degree of protection (to EN 60529)	<ul style="list-style-type: none"> • IP 65 with connector per EN 175301-803-A • IP 67 with M12 connector • IP 67 with cable • IP 67 with cable quick screw connection
	Electromagnetic compatibility	<ul style="list-style-type: none"> • acc. IEC 61326-1/-2/-3 • acc. NAMUR NE21, only for ATEX versions and with a max. measuring deviation $\leq 1 \%$

Design	Weight	Approx. 0.090 kg (0.198 lb)
	Process connections	See dimension drawings
	Electrical connections	<ul style="list-style-type: none"> • Connector per EN 175301-803-A Form A with cable inlet M16x1.5 or 1/2-14 NPT or Pg 11 • M12 connector • 2 or 3-wire (0.5 mm²) cable ($\varnothing \pm 5.4 \text{ mm}$) • Quickon cable quick screw connection
	Wetted parts materials	
	• Measuring cell	Stainless steel, mat.-No. 1.4016
	• Process connection	Stainless steel, mat. No. 1.4404 (SST 316 L)
	Non-wetted parts materials	
	• Enclosure	Stainless steel, mat. No. 1.4404 (SST 316 L)
	• Rack	Plastic
	• cables	PVC
Certificates and approvals	Classification according to pressure equipment directive (PED 97/23/EC)	For gases of fluid group 1 and liquids of fluid group 1; complies with requirements of article 3, paragraph 3 (sound engineering practice)
	Lloyd's Register of Shipping (LR)	12/20010
	Germanischer Lloyd (GL)	GL19740 11 HH00
	American Bureau of Shipping (ABS)	ABS_11_HG 789392_PDA
	Bureau Veritas (BV)	BV 271007A0 BV
	Det Norske Veritas (DNV)	A 12553
	Drinking water approval (ACS)	ACS 11 ACC NY 055
	GOST	GOST-R
	Underwriters Laboratories (UL)	
	• for USA and Canada	UL 20110217 - E34453
	• worldwide	IEC UL DK 21845
Explosion protection	Intrinsic safety "i" (only with current output)	Ex II 1/2 G Ex ia IIC T4 Ga/Gb Ex II 1/2 D Ex ia IIIC T125 °C Da/Db
	EC type-examination certificate	SEV 10 ATEX 0146
	Connection to certified intrinsically-safe resistive circuits with maximum values:	$U_i \leq 30 \text{ V DC}$; $I_i \leq 100 \text{ mA}$; $P_i \leq 0.75 \text{ W}$
	Effective internal inductance and capacity for versions with plugs per EN 175301-803-A and M12	$L_i = 0 \text{ nH}$; $C_i = 0 \text{ nF}$

Prilog 13: Senzor sile U9C

U9C

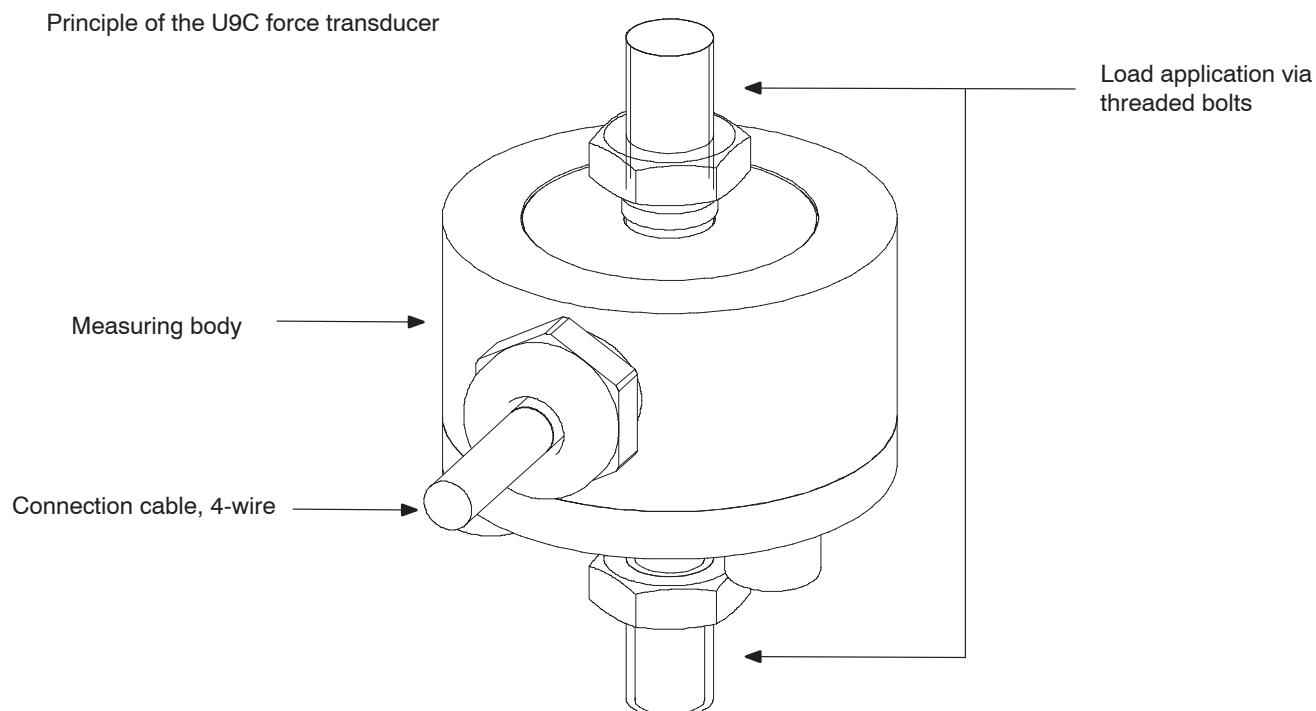
Force Transducer



Special features

- Tensile/compressive force transducer
- Accuracy class 0.2
- Nominal (rated) forces 50 N – 50 KN
- Non-rusting, protection class IP67
- Configurable with different cable lengths, plug assembly on request

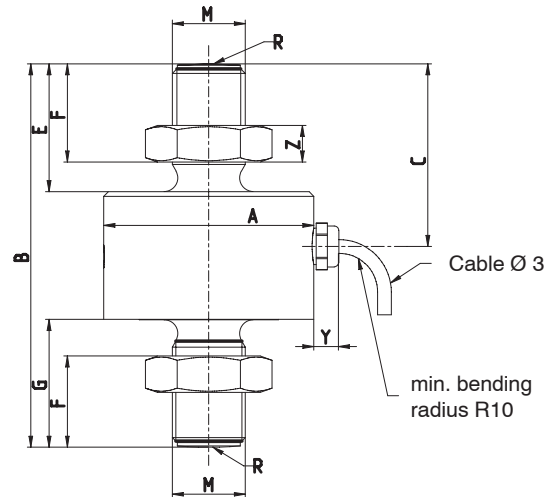
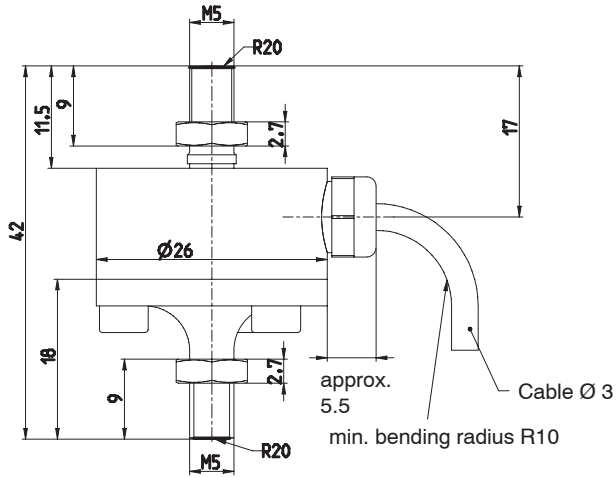
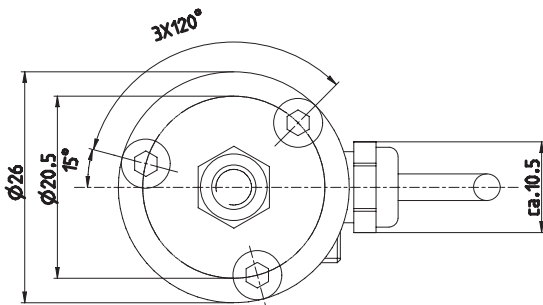
Principle of the U9C force transducer



Dimensions (in mm)

U9C with nominal (rated) forces 50 N, 100 N and 200 N

U9C with nominal (rated) forces 0.5 kN to 50 kN



Nominal (rated) force of the U9C	A-0.1	B	C	E	F	G	M	R	Y	Z
	[mm]									
0.5 kN to 1 kN	26	44.5	29.5	13	9.9	13.5	M5	20	approx. 5.5	2.7
2 kN to 20 kN	26	60	28.5	21	16	21	M10	40	approx. 5.5	5
50 kN	46	84	40	28	21.5	28	M16 x 1.5	80	approx. 5.5	8

U9C cable diagram

